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WRITING IN SCIENCE: INFLUENCES OF PROFESSIONAL DEVELOPMENT ON TEACHERS' BELIEFS, PRACTICES, AND STUDENT PERFORMANCE

by

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A dissertation submitted in partial fulfillment
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May 2012

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ABSTRACT

Writing In Science: Influences Of Professional Development On Teachers' Beliefs, Practices, And Student Performance

by

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Science education reform calls for learners to be engaged in hand-on, minds-on activities related to science. As a part of this reform effort, learners are encouraged to use writing as a means of documenting their work and developing their understandings. This qualitative case study employed the Conceptual Change Perspective and Sociocultural Perspective to examine the impact on three elementary teachers' beliefs, practices, and student outcomes, as they relate to science notebooks, based on their participation in a professional study group. Data sources included teacher and student interviews, video of the study group meetings, video of classroom lessons, and student work in the form of science notebooks and pre- and posttests. Results show that the study group discussions focused on the science notebook as a tool, the teacher's role, the students' struggle to write, and the content of the notebook. Individual cases were developed and then a cross-case analysis was conducted. Results of this analysis suggest that the longer a teacher is involved in a study group, the greater the impact on her beliefs and practices, which resulted in students being able to define a purpose for the notebook, having a higher percentage of the parts of a conclusion within their notebooks, and demonstrating an

understanding of the scientific content. Based on the analysis, a substantive theory on the development of insightful implementation of science notebooks was developed. This study has implications for both the elementary classroom and teacher education programs in helping teachers learn reform-based practices that facilitate student learning. Finally, suggestions for future research are considered.

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DEDICATION

To my mom and dad,

thank you for always believing in me.

I love you.

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CHAPTER 1

INTRODUCTION

In 1996 the National Research Council (NRC) published the *National Science Education Standards* (NRC, 1996) as a roadmap for how teachers and schools could meet the goal of scientific literacy for all. Scientific literacy is defined as

> the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. … Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. (NRC, 1996, p. 22)

In order to achieve this goal of scientific literacy as outlined above, the NRC calls for reform at all levels utilizing inquiry-based instruction that requires students to identify assumptions, use critical thinking, and consider a variety of explanations. An important component of this type of learning is the oral and written discourse in which students are engaged in order to connect their ideas to the larger world outside of the classroom. The *Benchmarks for Science Literacy* (AAAS, 1993) states "students should be required to keep written records in bound notebooks of what they did, what data they collected, and what they think the data mean" (p. 286); furthermore, it states that students "should learn that writing things down and drawing pictures can help them tell their ideas to others accurately" (p. 197). *A Framework for K-12 Science Education* (NRC, 2011) asserts

> "[f]rom the very start of their education, students should be asked to engage in the communication of science… students should write accounts of their work, using journals to record observations, thoughts, ideas, and models. They should be encouraged to create diagrams and to represent data and observations with plots and tables, as well as with written text, in these journals. They should also begin to produce reports or posters that present their work to others." (p. 3-21)

The *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* (*CCSS*) (CCSSO & NGA Center, 2010) also emphasize the importance of writing within the content areas in order for students to be ready for college and careers. The *CCSS* states that teachers should use their "content area expertise to help students meet the particular challenges of reading, writing, speaking, listening, and language in their respective fields" (p. 3). However, it is also clearly states that the *CCSS* should serve as a supplement to the content standards rather than as a replacement for them.

Based on the above ideas, researchers have stated that educators should consider language and writing as an integral part of doing and learning inquiry-based science (Baker et al., 2008; Yore, Florence, Pearson, & Weaver, 2006). The NRC (1996) states that inquiry-based science "requires … students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science" (p. 105). At the elementary level, many teachers utilize science notebooks as a way to incorporate these ideas and to encourage students to write within science (Baxter, Bass, & Glasser, 2001; Campbell & Fulton, 2003; Fulwiler, 2007; Gilbert & Kotleman, 2005; Rivard, 1994; Rowell, 1997; Shepardson & Britsch, 2004; Worth, Winokur, Crissman, Heller-Winokur, & Davis, 2009). While teachers utilize science notebooks, many struggle with what writing within the notebook should look like

and how to implement it in a manner that leads to the development of scientific understandings (Ruiz-Primo, Li, Tsai, & Schneider, 2010).

Their struggles are not surprising though, as most resources and workshops tend to focus on the elements of science notebooks and the types of writing they might contain (Aschbacher & Alonzo, 2006; Campbell & Fulton, 2003; Mintz & Calhoun, 2004) rather than the more complex tasks needed to make sense of the data, such as written conclusions containing evidence and explanations. These experiences form the basis for teachers' beliefs that students should focus primarily on recording observations and procedures within their notebooks. While this is a beginning point, it does not allow students to make sense of the data and develop the critical thinking skills that help them achieve not only in science but in reading, writing, and mathematics as well (Pearson, Moje, & Greenleaf, 2010). As a science mentor and project facilitator, I have worked with teachers who seem to believe that notebooks are an important component of science, but struggle to use them to their full capacity. For example, they may ask students to record but focus on the basic elements rather than the development of conclusions, or they may ask students to read from their notebooks rather than use the information within to defend their thinking.

To help change this, I implemented a school-based study group focused on science notebooks and the development of strategies to facilitate students' critical thinking in science. My work with this study group has led me to the questions that frame this study:

1. How are teachers' beliefs and practices, as they relate to the use of science notebooks and write-to-learn strategies, impacted by participation in a study group focused on science notebooks?

2. How do these beliefs and practices influence student performance in terms of notebook development and understanding of scientific concepts?

In this chapter, I provide a rationale for studying these problems as well as the significance of such a study. Within the rationale, I first examine the role and purpose of writing in science, including science notebooks and student performance. Then I consider the struggles teachers encounter in integrating writing within science and how learning communities, such as a study group, may help them develop these ideas.

Rationale

The Role and Purpose of Writing in the Context of Science

Writing in science helps clarify thinking and build understanding; however, teachers are unsure of how to use it in this manner. Instead they ask students to write about what they did during science time rather than using writing to construct knowledge. Scientists use a form of writing known as transactional writing (Keys, 1999). Through this kind of writing, they are able to construct their knowledge in order to inform their own practice and the practice of others in the community. More specifically Yore et al. (2006) state that "[s]cientists use writing to create permanent records to establish their priority for discoveries and as documented sources for reflection, analysis, and evaluation" (p. 113). Those permanent records sometimes take the form of notebooks, which may include sketches, calculations, notes, measurements, lists, and other forms of data (Campbell & Fulton, 2003).

However, writing is more than just a means of documentation for scientists, as it is an interactive and constructive process. As part of the inquiry process, scientists use evidence and scientific knowledge to develop explanations (NRC, 1996). They write to

develop claims and arguments about that which they are studying, to make generalizations based on data, to report their findings, and to persuade others (Yore et al., 2006). Many scientists see writing as a means to help them better understand their research, build upon their knowledge, generate new insights, discover errors in their work, and develop new areas of interest (Yore, Hand, & Florence, 2004). They also write to disseminate information to others, and place a priority on writing up their research for publication (Yore, Hand, & Prain, 2002).

Just as scientists use writing for a variety of reasons, so too should students. Traditionally, writing in school science has been used by the teacher as a means of evaluating students; however, over the past few decades, there has been interest in using writing as a means to learn science, also known as "writing-to-learn" (Keys, 1999; Rivard, 1994). Yore, Bisanz, and Hand (2003) describe this type of writing as the "minds-on complement to hands-on inquiry" (p. 712). Writing within the elementary science classroom has three main roles: as a means to transmit knowledge, as personal expression, and as a social practice (Rowell, 1997). It is in this final role, as a social practice, that student writing most replicates that of a scientist, as students work to construct meaning, transform knowledge, and learn the language and practices of scientists.

Writing in this manner becomes quite complex at the elementary level, especially with primary age students and those who may struggle with language, such as English Language Learners (ELLs), as most of these students are at the early stages of literacy development and are learning how to write in general. For many of these learners, writing in science becomes learning how to write through science. Writing becomes a

means to record what they are doing, to promote scientific thinking, and to further writing as a tool for communication.

Writing as a strategy for learning has received support from practitioners and scholars alike (Rivard, 1994; Rivard & Straw, 2000), but Yore et al. (2003) pointed out that the most effective programs make the instruction of science writing explicit for the students. These programs scaffold instruction through the use of writing heuristics, frameworks, and guides (Hand, Prain, Lawrence, & Yore, 1999; Ruiz-Primo, et al., 2010) in order to help students learn the scientific content and how to use scientific language when writing. In addition, such scaffolding focuses the students' writing on the content rather than the activity, helping them make connections between their current understandings and the new concepts presented. This idea of scaffolding stems from the work of Vygotsky (1978) and the idea that the teacher provides supports to help the student build on prior knowledge and develop the ability to complete similar tasks on his/her own. The idea behind providing scaffolds for writing in science is to begin with the students' preconceptions and "use a sequence of learning experiences that build on these ideas, usually helping students specifically consider how their ideas stand up to the evidence from investigations, the ideas of others, and scientific thinking" (Appleton, 2007, p. 514).

Baker et al. (2008) and Yore et al. (2003) have demonstrated that when writing within science is scaffolded, it promotes higher-level thinking and helps students develop an understanding of the more complex tasks of science, including scientific dispositions. The dispositions required in science – inferring, making sense, arguing based on evidence, and constructing meaning – are similar to those required of literate students (Century et al., 2002; Pearson et al., 2010). When developed in science, these

dispositions help students become scientifically literate as well, by building an understanding of scientific content, how scientists work, and a positive attitude towards science (Levitt, 2002; Windschitl, 2003; Yore et al., 2003).

The idea of scaffolding student writing aligns with the findings of process-product research, which states that "students learn more efficiently when their teachers first structure new information for them and help them relate it to what they already know" (Brophy & Good, 1986). Researchers in this field also have gathered evidence that certain teaching practices impact students' achievement in a positive manner. Impactful teacher practices include focusing on academic instruction, using organizers to structure material for students, explicitly stating important links, and focusing students' attention on the main idea (Hill, Rowan, & Ball, 2005). Similar practices are being called for in the area of writing in science, such as the use of frames to help structure the material or the use of focus questions to help guide student writing towards the scientific idea rather than the activity. The purpose of this study was to examine how teachers beliefs and practices about writing in this manner were influenced when they were provided with professional development focused on writing in the context of science.

Science notebooks.

Science notebooks serve as tools to help students develop scientific understandings; however, student writing within the notebook must be scaffolded to support this type of learning and focus on the science content rather than the science activity. It has been demonstrated that many teachers have students use science notebooks within inquiry-based science lessons as one means to incorporate writing in science (Baxter et al., 2001; Campbell & Fulton, 2003; Fulwiler, 2007; Gilbert & Kotleman, 2005); however, use of

science notebooks varies widely. Ruiz-Primo, Li, Ayala, and Shavelson (2004) describe science notebooks as

> a log of what students do in their science class. … Keeping science notebooks encourages students to write as a natural part of their daily science class experience. Students may describe the problems they are trying to solve, the procedures they use, observations they make, conclusions they arrive at, and their reflections. (p. 1477)

In some classrooms, the notebook may not be visible during science, but students may take them out at the end of the lesson. In this situation, the notebook serves as a journal in which the entries often reflect what was done in science that day and how the students felt about it. In other classrooms, the notebook may be out during science and students may be recording information within it, but then put it away at the end to never look back at that information. In this situation, the notebook serves as a "bound workbook" in which the students log the information required for that lesson, but do nothing more with it.

In other classrooms, students are using the notebook to record their observations and data during the lesson, to reflect on the scientific ideas through "focus questions" that focus their thinking on the big ideas, and to locate information during class discussions or writing projects. In this situation, the notebook serves as a learning tool that helps the students learn both the content and language of science. This final example emulates what notebooks should look like within elementary classrooms in order to promote higher-level thinking and an understanding of the complex tasks of science (Baker et al., 2008; Yore et al., 2003), yet this is rarely the way in which notebooks are used. If notebooks are to be used as learning tools then teachers need to understand what this looks like and how to help their students use them in this manner.

Student performance.

Great emphasis is placed on student performance as a result of No Child Left Behind (Marx & Harris, 2006). Teachers must be highly skilled in bringing about positive student results in all subject areas. Writing in science and the use of science notebooks have the potential for increasing the critical thinking skills students need to achieve in science as well as other academic areas (Pearson et al., 2010; Ruiz-Primo et al., 2010). Although student performance is often equated with student achievement on standardized tests, "there are many ways of measuring academic achievement, including work samples, portfolios, performance assessments, and other authentic assessments" (Konstantopoulos & Hedges, 2008, p. 1612). Within my study, these other forms of achievement are essential, as standardized tests in science typically take place during the intermediate grades. In addition, these other forms of assessment, such as writing within the science notebook, allow for a broader look at student performance, including students' understanding of the science content and the purpose of a science notebook.

In this study, students studied the content of physical science, which the *National Science Education Standards* (NRC, 1996) state should increase their understanding "of the characteristics of objects and materials that they encounter daily… [including reflection] on the similarities and differences of the objects" (p. 123). Their understanding of the content can be represented within their science notebook entries as well as on performance and written tests. However, there is more to science than understanding the content, as it is also about "the abilities to communicate, critique, and analyze their work" (NRC, 1996, p. 122), including the ability to articulate their thinking in writing and to use a science notebook as a learning tool, which are best assessed

through examining their notebooks and observing how they use them in these manners. These scientific standards form the basis for student performance within this study and need to be examined in order to understand the influence a teacher's beliefs and practices may have on the students' performance.

The Struggles Teachers Encounter in Integrating Writing within Science

Elementary teachers often state that they are not comfortable teaching science (Appleton, 2007; Banilower, Heck, & Weiss, 2007; Davis, Petish, & Smithey, 2006; Howes, Lim, & Campos, 2009). The above research shows that this discomfort is often due to: limited content and pedagogical knowledge, negative experiences with science, issues with management, and/or low levels of confidence with teaching science. Due to this discomfort many teachers will attempt to avoid teaching science or rely on the textbook or teacher's manual to get them through.

Furthermore, research shows that even if teachers feel comfortable teaching science, they do not feel prepared to teach writing in science and science using writing (Baker et al., 2008; Pearson et al., 2010; Rivard, 1994; Ruiz-Primo et al., 2010; Warwick, Sparks Linfield, & Stephenson, 1999; Warwick, Stephenson, Webster, & Bourne, 2003). Their discomforts here stem from their attitudes towards writing, constraints in terms of time and scheduling, a lack of understanding about the importance of writing-to-learn, and a lack of understanding of write-to-learn instructional strategies. Therefore, teachers do not provide students with explicit instructions that would allow them to use writing-to-learn strategies most effectively.

Of those elementary teachers who are comfortable teaching science using writing, many use science notebooks. Notebooks have been defined by Ruiz-Primo and Li

(2004), “as a compilation of entries (or items in a log) that provide a record, at least partially, of the instructional experiences a student had in her or his classroom for a certain period of time” (p. 62). Writing within the notebook differs but ranges from such things as observations, drawings, notes, and plans, to reflections, explanations, and conclusions. Often times the level of this writing is mechanical in nature focusing on procedural tasks and recording rather than the more complex tasks of explanation and application (Baxter et al., 2001; Ruiz-Primo & Li, 2004; Ruiz-Primo et al., 2004); this may be influenced by the definition of science notebooks which seems to focus more on procedural and recording tasks.

If teachers’ understandings and experiences with notebooks focus on recording and planning, then they probably believe that notebooks should be used to document the science activity rather than as a means to facilitate thinking through writing. Research (Walls, Nardi, von Minden, & Hoffman, 2002; Watters & Ginns, 1995) demonstrates that the foundation for teachers’ beliefs stem from their personal experiences, their formal training, and their experiences in the classroom. These beliefs in turn shape classroom instruction (Cobb & Bowers, 1999; Pajares, 1992). If teachers are expected to help students develop complex forms of writing, which replicate the writing of scientists and push students to higher-level thinking, teachers need to understand the importance of writing in this manner as well as how to support students to write in this way. More research is needed in this area to understand how teachers can be supported in developing these ideas and how such support impacts their beliefs and practices.

Naively, some have suggested that teachers can overcome their discomfort or lack of understanding by taking more science content courses within their pre-service program,

but research shows that most have an adequate number of courses (Davis et al., 2006) and that preparation in content does not always provide them with the instructional strategies needed for initiating the reform efforts (Appleton, 2007). Pearson et al. (2010) state that curriculum, teacher preparation programs, and professional development will all need to change if the ideal relationship between science and literacy is to be achieved in the classroom. Appleton (2007) agrees with the idea that professional development must change and states that it should focus more on providing teachers with opportunities to develop ideas through peer discussions rather than trying to grasp ideas through lectures or readings. By learning in this way, teachers are more likely to take these same practices back to the classroom. If teachers are expected to utilize writing as a thinking tool rather than just a recording tool, then they need professional development that helps them understand the importance of using writing in this way and how to implement it with students.

The Role of the Study Group

Traditionally, professional development has been delivered through "top-down 'teacher training'" (Darling-Hammond & McLaughlin, 1995, para 2); however, in the past two decades this has shifted and teachers now have a role in their professional learning (Darling-Hammond & McLaughlin, 1995). Based in the conception of "knowledge-of-practice" (Cochran-Smith & Lytle, 1999, p. 273), Cochran-Smith and Lytle (1999) noted that teachers played a critical role in constructing the knowledge they needed through collaborative groups, in which all members functioned as researchers and learners together. The role of these collaborative groups was to provide a context in which teachers could critically examine their assumptions and practices and construct

knowledge. Based on this idea, different forms of learning communities began cropping up in schools. One such form was a study group, defined by Birchak et al. (1998) as

> a voluntary group of people who come together to talk and create theoretical and practical understandings with each other. … all groups share the focus on transforming teaching through dialogue and reflection and on creating a sense of community among teachers. (p. 28)

Such study groups have been found to impact the way in which participants think about their practice and their abilities to utilize different perspectives when thinking about their discipline (Wildman, Hable, Preston, & Magliaro, 2000). Grossman, Wineburg, and Woolworth (2000) found that the professional communities created in one school led to intellectual renewal for the teachers involved as well as a new understanding of the content. In reviewing several large-scale studies, Wei, Darling-Hammond, Andree, Richardson, and Orphanos (2009) found that professional learning communities, such as collaborative groups, led to academic gains for students, a shared purpose among teachers, the development of additional instructional strategies, and the implementation of successful practices. However, in this report Wei et al. also found that the United States lagged behind other high-achieving countries in providing these types of collaborative learning opportunities.

The purpose of my research was to focus on a school-based study group, formed voluntarily by teachers interested in learning more about science notebooks and how to implement them in their classrooms. The teachers served as the "experts," bringing with them the knowledge and questions they had from their classrooms. I, too, was a member of the study group and helped coordinate and facilitate the meetings and compiled and shared resources based on the group's discussions. While professional communities in

general have been shown to be beneficial, little research examines the impact of study groups, especially in the area of writing in science. This study fills that void.

CHAPTER 2

THEORETICAL AND EMPIRICAL REVIEWS

In the last chapter, I established the need for research to explore the relationships between professional development, teachers' beliefs and practices, and student outcomes pertaining to the use of write-to-learn strategies within the science notebook. In this chapter, I first consider the theoretical frameworks that will serve as lenses for exploring and understanding this type of research. I base my work in two theories, conceptual change and sociocultural theory. Then, I review the empirical literature to better understand the current fields related to these questions. More specifically, I examine the literature related to writing in science, including science notebooks; teachers' beliefs and practices related to the implementation of reform-based science instruction; and professional development. Finally, I identify the gaps within the literature and how a study based on the above questions will deepen and extend current understandings.

Theoretical Framework

I utilized two frameworks to frame the focus of this study and guide the design of the study. The Conceptual Change Perspective allowed me to frame the change in the teachers' beliefs and practices related to science notebooks and how to develop writing in science. Building off this base, I use the Sociocultural Perspective to frame the study group as a community of learners that may have influenced this change, as well as the teachers' practices within the classroom and how she helped scaffold student learning.

Conceptual Change Perspective

The conceptual change perspective has had a strong influence on science education, (Anderson, 2007; Duit & Treagust, 2003; Zembylas, 2005). Based on Piaget's (1929,

1930, 1974) work of how individuals make sense of their world, Posner, Strike, Hewson, and Gertzog (1982) wrote a seminal article on the theory of conceptual change in which they describe how a person's prior understandings serve as the means for making sense of new concepts. They stated that people do this either through assimilation or accommodation. In order to accommodate new information, individuals must go through four stages. These stages include: a) the current conception is causing dissatisfaction, b) the new conception is considered intelligible, c) the new conception appears to be plausible, and d) the new conception can be seen as fruitful. Duit and Treagust (2003) refer to conceptual change as the best-known model in science education, and state that it is "a powerful frame for improving science teaching and learning" (p. 683).

Based on this theory, new information is assimilated or accommodated based on an individual's prior conceptions. If individuals have strong beliefs about an idea, it will be more difficult to change that conception; however, if they are dissatisfied with their current conception, this change is more likely to take place. In this study, the teachers shared that, prior to joining the study group, they had used science notebooks in the classroom, but they were unsure of what this should look like or voiced dissatisfaction with what they saw students doing. They joined the study group looking for new ideas, looking for change. The impact of the conceptual and practical change, related to science notebooks, that each teacher experienced was a result of what they learned in the professional development, what they took back to their classrooms, and what they learned as a result of implementing the new ideas with their students.

The original theory of conceptual change has been criticized as being one-sided towards cognitive factors (Duit & Treagust, 2003). While cognitive factors are important

in learning, Duit and Treagust (2003) point out that affective factors, such as motivation, beliefs, and self-efficacy are important to consider as well. This is further supported by Pintrich, Marx, and Boyle (1993) who state, "that the process of conceptual change is influenced by personal, motivational, social, and historical factors" (p. 170), and by Zembylas (2005) who states that "the holistic picture of learning is lost … [if] the learners' emotions, attitudes and beliefs as well as the social and emotional aspects of learning in a classroom community" (p. 95) are not considered. In this study, these affective factors played out for the teachers as they worked to change their concept of notebooks from that of a recording tool to that of a learning tool within a collaborative study group. This process of learning was not done in isolation, but was influenced by the interactions between teachers and between a teacher and her students. The interactions that took place within the study group and within the classroom influenced the process of conceptual change, making one's experiences very different from another's. These differences are important to consider to completely understand the changes that are taking place. For this reason, I utilized Pintrich et al.'s model for conceptual change, which looks at values, goals, control beliefs, and self-efficacy as mediators in the conceptual change process, to determine what types of factors may have influenced the change process for each of the teachers.

Pintrich et al.'s (1993) model suggests that the above factors can influence a learner's ability to change their conceptual framework. For example, the learners' interests and values are personal characteristics that they bring to the task and cause them to be engaged on different levels. Based on this idea, Pintrich et al. state that tasks should be presented in such a way that they engage the learner cognitively, but do not stretch their

interests or values too much, as this would interrupt the change process. Furthermore, the goals and timing of the task are also important to consider, as change takes time. In the study group, these teachers have engaged in science notebooks, but have volunteered to participate in the study group to develop their use of the notebook. This allows them to engage cognitively, but does not push them too far because they are already using the notebooks.

Duit and Treagust (2003) refer to the merging of conceptual domains with affective domains as providing a multi-perspective of science learning and teaching. They state that such "frameworks allow researchers to model teaching and learning processes sufficiently and to address the ambitious levels of scientific literacy" (Duit & Treagust, 2003, p. 680). The teaching and learning of writing in science is a complex process that involves both conceptual and affective factors. The group dynamics involved in this study add a social aspect that may influence both factors, which situates it in Pintrich et al.'s (1993) model. This model allowed me to examine the change teachers experienced, however, I also considered the role the study group played in bringing about this change and how they implemented it within their classrooms through a sociocultural lens, which will be described next.

Sociocultural Perspective

While conceptual change assumes that individuals can change their views about a topic without having to change their identity or other parts of their life, the sociocultural perspective sees these views, or beliefs, as being tied to a complex web of practices related to the community with which they are associated, as change "is a social process with social consequences" (Lemke, 2001, p. 301). The collaborative study group and the

classrooms of the teachers each constitute complex communities in which the teachers' and students' understandings are being shaped by the practices playing out. Within this model, learners develop new ideas based on interactions with others rather than their current ideas. These interactions are representative of the teacher's belief system and the community they have helped establish. Within this research, teachers and students are developing an understanding of why writing in science is important and how to do that based on the scaffolded interactions they have with their peers and teachers, situating this study in the sociocultural perspective.

Based in the sociocultural perspective, the work of Lave and Wenger (1991) focuses on the concept that the ideas we learn are products of the situation and activity in which they were produced. This is the basis for situated learning theory (Lave & Wenger, 1991), which sees the development of understandings as dependent upon the context and culture in which the learning occurs. Anderson, Reder, and Simon (1996) examine four premises for situated learning. Those premises are: (a) actions are grounded in the situation in which they occur, (b) knowledge tied to one context of learning can only be transferred to similar contexts, (c) abstract training must be connected with concrete examples to be useful, and (d) learning should take place in a social environment that is complex and robust. These four premises were used to consider the role the group played in bringing about changes within the teachers' understandings, how they put these understandings into practice with their students, and how this influenced their students' learning.

The study group constitutes a community of learners (Rogoff, Matusov, & White, 1998), from one school, interested in learning the discourse of scientific writing. They

come together to examine student notebooks, share strategies, and discuss ways in which they can facilitate student learning. They then take ideas back to the classroom and implement them with students. These teachers have established a culture of teaching and learning related to inquiry-based scientific writing that allows them to grow and learn as professionals. As members of a study group community, they are learning the language and activities of that community. This in turn shapes their identity and actions as they develop knowledge and skills. In turn, the teachers establish a culture of scientific discourse within their classrooms, which allow their students to grow and learn. Next, I examine how this theory provided a lens in which to examine the teacher's practices.

Vygotsky (1978) surmises that learning moves from social to individual understanding. As people come into contact with new ideas in a social setting, such as the classroom, they practice those ideas through talk, actions, writing, and other forms of language on what Vygotsky called the *social plane*. As the individual takes this information in and begins to make sense of it for himself, he moves from the social plane to the *individual plane*. In the classroom, "it's the job of the teacher to make scientific knowledge available on the social plane" (Scott, Asoko, & Leach, 2007, p. 40). The activities the teacher provides for the student directly influences his interactions on both the social and individual planes and hence his learning. Borko (2004) also recognizes learning as a social practice and sees our interactions with others as a factor in determining what we learn and how we learn it.

The sociocultural perspective has gained recognition by science educators in the past ten years as a means to focus on the "the culture and language of scientific communities" (Anderson, 2007, p. 14). This work stems from other sociocultural work that analyzes

the language people use in different situations, such as that done by Cole, Gay, Glick, and Sharp (1971), Gee (1996), and Lave and Wenger (1991).

While sociocultural methods serve as a valid means of science education research, Anderson (2007) shares that it does present some challenges. First, it is difficult to quantify and therefore prescribe to others ways in which to reproduce the results. Second, those trained in sciences are not usually as aware of the anthropological and linguistic concepts that are a central part of the research, making it more challenging for the researchers (Lemke, 2001). Despite these challenges, strong examples of research in the field of science education utilize sociocultural ideas. Roseberry, Warren, and Conant (1992) studied the impact collaborative inquiry-based science had on English Language Learners' (ELLs') abilities to understand concepts and reason in a scientific manner. Moje, Collazo, Carrillo, and Marx (2001) studied the discursive demands placed upon seventh grade ELLs as they participated in project-based science lessons. The work of Roseberry et al., Moje et al., and Lemke (2001) all focused on linguistic aspects related to science. Since the present study focused on the development of the linguistic aspects of writing in science, the sociocultural perspective serves as an appropriate frame.

Vygotsky (1986) noted written language is more demanding than the spoken word due to the symbolic and abstract nature of it. In *Thought and Language* (1986) Vygotsky distinguishes between two types of thinking, spontaneous and scientific. Children encounter spontaneous concepts through their play or through the orchestration of the teacher and utilize egocentric speech as they work with the materials. This egocentric speech eventually becomes inner speech as the child internalizes the spoken words. As children struggle to internalize language, the discourse of science adds another

dimension, as it is a specialized system that is often unfamiliar to students (Lemke, 1990), making it even more difficult for them to talk and write about it (Lee & Fradd, 1998). While science learning focuses on hands-on experiences, the language of science cannot be learned using only these methods (Carlsen, 2007). Therefore, it is essential that the teacher introduce students to this type of discourse through the use of scaffolds that can be used when talking and writing about science concepts. If such scaffolds are introduced to the class on the social plane and children are allowed to make sense of them, moving them into their individual plane, they will be able to integrate them into their thinking and therefore the writing within their science notebooks.

As part of this scaffolding, Vygotsky stated that learners should receive the language before experiencing the phenomena so as to have the language to describe the experience (Mitchell & Myles, 2004). This is in contrast to Piaget's idea that individuals make sense of their world and develop language as a result of their experiences (1929, 1930, 1974), confounding the argument of vocabulary instruction and writing in science. If notebooks are to serve as tools, students need the opportunity to develop their ideas and language, following Piaget's ideas, rather than receiving it up front as Vygotsky would promote. Regardless, Vygotsky's theories of scaffolding and Zone of Proximal Development provide a solid framework for good science instruction in terms of moving students toward independence (Schutz, 2004).

Lemke (2001) states that working within the sociocultural perspective in science education means viewing it "as human social activities conducted within institutional and cultural frameworks" (p. 296). As children grow and learn within the classroom, they are

part of that social organization which provides them with tools for sense making. More specifically, in the current study, the way in which the teacher structures writing within science gives the students tools that help them make sense of why writing is an important component of science, understand how the notebook should be used to convey ideas, and articulate these reasons to other individuals.

While each student is unique and develops in his or her own way, the teacher and her beliefs influence the ways in which her students utilize and view writing within the science notebook. To understand the practices a teacher employs and specifically how she teaches writing in science, I looked at how students were being taught to engage with writing and science concepts within the culture of their classroom, which is another aspect of the sociocultural perspective.

These two perspectives, conceptual change and the sociocultural perspective, served as the lenses through which I analyzed this study. Each provided views on different aspects of the study and allowed me to gain insights through analysis of the data.

Empirical Literature Review

The idea of writing in science for more than the purpose of evaluating students goes back a couple of decades (Keys, 1999; Rivard, 1994); however, the work around science notebooks is younger yet (Baxter et al., 2001). Due to the immaturity of this line of research, the connections between the practices of writing in science, including the use of science notebooks; professional development; and teachers' beliefs is not clearly defined in the literature. To understand the issues pertinent to this research, a review of the relevant empirical literature was conducted in each of the following areas: writing in science, including science notebooks; teachers' beliefs related to the implementation of

reform-based science instruction; and collaboration as a form of professional development. For each topic, I will outline my research trail, review and critique the literature, and provide a synthesis of the findings along with implications and suggestions for future research.

Writing in Science

To understand the role of writing in the area of science, a review of the literature was conducted. I searched three databases using the terms "writing," "science," "write-to-learn," "language," "writing in science," and "science notebooks." The databases included Professional Development Collection, ERIC, and Education Full Text. These searches resulted in over 200 articles, of which there was some overlap. Several articles were eliminated due to their focus on practitioners, post-secondary levels of education, or unrelated topics. Finally, a review of selected articles' references was used to determine other studies that related to the topic. This resulted in twelve articles that met the criteria of being empirical and focused primarily on elementary aged students.

Writing has been promoted as a powerful means to help students develop conceptual understandings in science (Rivard, 1994); however, in order to develop these types of understandings, teachers need to provide explicit instruction that scaffolds students' thinking and writing (Yore et al., 2003). This type of writing is often incorporated into inquiry-based science through the use of science notebooks (Campbell & Fulton, 2003; Fulwiler, 2007; Worth et al., 2009). It is important to understand how writing in science impacts student achievement in science, what this explicit instruction looks like, and how notebooks are used as a means to incorporate it. Within this section, I examine these three aspects.

Impact on student achievement.

Writing in science, when scaffolded appropriately, has the potential for enhancing students' conceptual understandings of science. Below I describe three studies that have looked at the impact writing in science has had on student achievement.

Lee, Mahotiere, Salinas, Penfield, and Maerten-Rivera (2009) conducted a quantitative study to examine students' writing achievement, including form and content, as part of a five-year study focused on improving English Language Learners' achievement in science and literacy. Seventy-five third-grade teachers at six schools received up to five days of professional development on developing ELL students' English-language through inquiry-based, hands-on science. Using pretests given in the fall and posttests given in the spring, 2,020 student tests were scored for writing and content. Differences between pre and posttests were calculated, showing significant gains by students, which increased significantly based on the number of years the teacher was involved in the "treatment." This is significant to my study since I am looking at teachers who have participated in professional development for various amounts of time. Overall, the research of Lee at al. indicates that science can be a vehicle for literacy development.

Choi, Notebaert, Diaz, and Hand (2010) determined that the Science Writing Heuristic (SWH) Framework was helpful in assisting students at years 5 (13 students), 7 (38 students), and 10 (56 students) in developing a written argument, or conclusion, in science and that students' arguments got better over time. An interesting component was the fact that year 5 students actually produced the strongest arguments, dispelling any ideas that maturation is an important component of the development of arguments, an

important aspect for my study, since I am looking at second grade students. The teachers involved in this study all had extensive training on the use of the SWH. To produce stronger arguments, the authors stated that teachers should focus instruction on claims and evidence and the relationship between them.

Tucknott and Yore (1999) also examined student achievement as a result of implementing writing-to-learn in science with a fourth grade class. Using a pre and posttest, they determined that students' conceptual understandings increased as a result of students' writing. Specifically, the students showed a gain of 38% on the recall portion and 51% on the higher-level comprehension questions. They assert that writing instruction in science should be explicit and extended over a longer period of time for lower ability students to benefit. They found that teachers must provide students with a clear purpose and explicit instructions when assigning writing activities, which is important to this study.

The three studies in this section demonstrate that the use of strategies to support writing in science can have a positive impact on student achievement, in both science and literacy development. They demonstrated that the teacher's role is an important component (Choi et al., 2010; Tucknott & Yore, 1999), gains increased over time (Choi et al., 2010; Lee et al., 2009), and maturation is not a factor to developing conclusions (Choi et al., 2010). While this information is important, Lee et al. (2010) did not explicitly define the strategies teachers learned about and used, leaving this open to interpretation. Neither Tucknott and Yore (1999) nor Choi et al. (2010) provided a clear example of what they considered to be excellent examples, leaving the reader to interpret what a strong conclusion looks like. An explicit connection between these aspects is

needed to fully understand the ways in which writing in science influences student achievement. My study addressed these issues by examining the strategies teachers used and the impact this had on student performance, providing examples of conclusions.

Explicit instruction on writing in science.

For students to benefit from writing in science, instruction should be explicit and scaffolded in some way. In this section, I look at three studies that examine explicit instruction on writing in science. The SWH has proven to be an effective framework in supporting students' development of written arguments at the secondary level (Akkus, Gunel, & Hand, 2007; Grimberg & Hand, 2009; Hand, Wallace, & Yang, 2004). Other forms of explicit teaching have demonstrated that similar templates promote student writing in science at the elementary level. Warwick, Sparks Linfield, and Stephenson (1999) examined the writing of 40 students, age 11, from England and found that their writing focused on what they had done in science rather than their thinking or understanding of the concepts. However, in talking with the students, they determined the students could express themselves better verbally than they could in writing. This led them to question if frames could be used to support student writing in science. In a second study, Warwick, Stephenson, Webster, and Bourne (2003) pursued this idea and found that writing frames supported 12 students, years 4, 6, and 7, from England in producing written work that mirrored their spoken understandings of science concepts. While they determined the frames were effective, they also noted that the degree of effectiveness depended on the way the teacher introduced the frames and had students use them. The authors did not examine student work that was generated without frames, so it is difficult to determine the extent to which the frame supported the students writing

in science and what they would have been capable of on their own. While one may assume that the frames helped students generate higher-level writing, this should be examined.

Patterson (2001) found that context maps could be used to scaffold student writing in science. Working with 12 students from grades 2, 3, and 6, she found that students produced more writing when using a structured context map and that they were able to provide reasons and make inferences. If students used an unstructured context map, they still wrote more than they did without it, but they focused on facts and descriptions. Based on her findings, Patterson concluded that the use of context maps improves students' understanding of the science concept. While Patterson was able to show that students generated more explanations when using the context map, it seems like a big jump to conclude that it improved their understanding of the science concept without some sort of pre/post test to demonstrate this level of understanding.

These studies confirm that explicit instruction on writing in science promotes the development of conceptual understanding. More specifically, they look at the use of frames (Choi et al., 2010; Warwick et al., 2003) and maps (Patterson, 2001) as a means to support student development. They point to the important role the teacher plays in helping students develop this understanding and state the need for more explicit instruction in this area. Most of these studies were done with older elementary students, so it is unknown how successful these strategies might be when used with younger elementary students who may have limited language development. In addition, most of the studies concluded that the effectiveness of these strategies depends upon the teacher and how the strategies are implemented. More research is needed on how teachers learn

to implement these strategies and the resulting impact this has on student learning, as the field of writing in science is young and there is much to be learned, especially at the elementary level (Keys, 1999; Pearson et al., 2010; Rivard, 1994; Rowell, 1997). My study filled this gap by examining how the teacher utilized such strategies within the primary classroom.

Science notebooks.

Science notebooks are used in many classrooms. In this section I look at five studies that examine how they are being used. Baxter, Bass, and Glasser (2001) studied the ways in which teachers facilitated science notebook use. They observed 7-8 lessons in three fifth grade classrooms and examined the science notebooks of 83 students from an urban school district. The teachers involved had access to extensive professional development focused on inquiry and implementation of the science curriculum. The researchers analyzed the lessons and notebooks focusing on the purpose, nature of writing, feedback, and organization.

Baxter et al. (2001) then compared the observations and notebooks to determine how teachers shaped writing in science for their students. Overall, the authors determined that notebooks are being used in a mechanical manner that contradicts the role of notebooks as a writing to learn strategy. The authors stated that extensive professional development was available on inquiry and the curriculum; however, they did not mention the role notebooks might have played in those professional development sessions, nor how much professional development the teachers attended. This type of data should be considered.

Other research on science notebooks (Aschbacher & Alonzo, 2006; Ruiz-Primo, et al., 2004; Ruiz-Primo et. al, 2010) has also found that notebooks are used in a mechanical

manner. Aschbacher and Alonzo (2006) analyzed 250 notebooks of fifth graders, of which 70 came from teachers who participated in 25 hours of training on science notebooks. In analyzing the notebooks, patterns emerged that showed too little guidance, too much guidance, or just the right amount of guidance by the teacher. The authors determined that the majority of teachers lacked the needed strategies and knowledge about the scientific content to provide guidance for the notebooks.

Ruiz-Primo et al. (2004) examined 72 notebooks of 36 fifth graders whose teachers had received training on implementation of the science curriculum, but had not been given any instructions for notebook use. They found that most entries focused on reporting data, recording definitions, and responding to short-answer questions. This study demonstrated that without appropriate professional development, teachers relied on past experiences and used notebooks primarily for recording purposes.

In another study Ruiz-Primo et al. (2010) explored the link between written explanations and students' performance on assessment. They examined the notebooks of 72 middle school students, as well as their pre/post assessments. They concluded "engaging students in the construction of explanations is likely to have a positive impact in students' learning and achievement of the content" (p. 604), but acknowledged the difficulty of accomplishing this as teachers do not seem to be aware of the importance of explanations and have varying degrees of understanding and implementation.

An early study by Shepardson and Britsch (2001) examined children's use of written language in the science journals of 18 Kindergarteners and 20 fourth graders. They found that students framed their understandings through three mental contexts, which helped them connect their new and prior ideas. They suggested that journals could be

enhanced if children were allowed to write and draw in a manner that was meaningful to them. This finding may be too open ended for some teachers; however, it points to the importance of not using notebooks in the mechanical manner described in the above research.

These studies confirm that notebooks are being used within science classrooms; however, they portray this use as mechanical and prescriptive (Aschbacher & Alonzo, 2006; Baxter et al., 2001; Ruiz-Primo et al., 2004). Teachers need a better sense of how to structure writing within notebooks to promote the learning of scientific concepts rather than as a means to capture what was done in science. In order to accomplish this, teachers need opportunities to learn and discuss strategies that will help students accomplish this goal. Only one of these studies utilized any type of professional development on science notebooks. Research needs to examine not only how notebooks are being implemented, but also how teachers are learning to implement them.

I examined the impact professional development, in the form of a study group focused on science notebooks, had on teachers' beliefs and practices as well as student outcomes. This group had participants from first through fifth grade. Based on the idea that much of the research conducted has focused on the intermediate grades (Appleton, 2007), I filled this gap by focusing on primary grades to learn how teachers help younger students develop not only conceptual understanding but writing ability as well. Finally, I linked the ideas learned in professional development to student practices/outcomes with the science notebook by examining student work.

Teachers' Beliefs Related to the Implementation of Reform-based Science Instruction

To understand the issue of classroom practice in the area of science, a review of the literature was conducted. The literature came from three databases, using various combinations of the search terms "classroom practice," "science," and "beliefs" and limited to articles published from 2000 to the present. The databases included Professional Development Collection, ERIC, and Education Full Text. These searches resulted in over 100 articles, of which there was some overlap as well as many articles that dealt with social and technological sciences; the latter were eliminated. Finally, a review of selected articles' references was used to determine other studies that related to the topic. This resulted in five articles that met the criteria of being empirical studies that focused on teachers' beliefs related to the teaching of science in accordance with the National Science Education Standards (NRC, 1996). In this section, I review the empirical studies focused on beliefs.

Beliefs.

Beliefs are often deeply rooted in individuals and stem from their own personal experiences. An individual's beliefs can impact the way in which reform-based science is implemented, which ultimately impacts student learning. Therefore, it is important to examine what we currently know about beliefs in order to understand how a teacher's beliefs about science notebooks might be impacted by participation in a study group. In this section, I will review five studies.

Keys (2005) established two categories of beliefs, entrenched and expressed, based on their analysis of data from working with seven experienced teachers. Entrenched

beliefs were those beliefs the teachers actually implemented in their classroom and were found to be the foundation of the teachers' actions. Expressed beliefs were those that teachers stated they believed, but were not evident in their lessons and were broken down into four categories. Expressed beliefs were often highly desired but required sacrifices that the teacher was unwilling to make. Keys stated that an understanding of the two sets of beliefs can help professional developers work with teachers on their transitional beliefs in order to bring teaching of the science curriculum closer to what it is intended to be. To establish this belief structure, Keys analyzed the data through the use of composite teachers. While this is an interesting way to look at the data, it is unclear how these composites were created and therefore how well they represent teachers as a whole.

Many times teachers' beliefs are confronted when they are asked to implement something new. In science, this is often the case when teachers are asked to implement inquiry-based science that aligns with reform efforts. Stoffels (2005) found that two teachers were extremely critical of the new curriculum, but relied heavily on it to guide their teaching. It appeared as though the teachers were more concerned about getting through the materials than ensuring that their students were learning the content. In other words, they were teaching it in a very mechanical manner. Citing time constraints as one reason for teaching in this manner, the teachers were able to excuse the discomforts they were feeling from the misalignment of the curriculum to their beliefs.

A similar mechanical implementation was found by Pekmez, Johnson, and Gott (2005) in eight secondary teachers implementing a new curriculum. The authors concluded that the implementation of innovations would be effective only if teachers recognized and valued a need for change. In order to establish this need for change,

teachers needed a deeper understanding of the content. While these two studies paint a bleak picture, Peers, Diezmann, and Watters (2003) demonstrated that through professional development and ongoing collegial support, a teacher was able to move from a highly procedural, teacher-centered approach to a student-centered approach. At a two-year follow-up, it was found that he was still teaching in this manner. He attributed his change to the collegial support that he believed challenged his thinking.

Akerson, Cullen, and Hanson (2009) studied the impact on teachers' beliefs and practices related to the Nature of Science (NOS) based on their participation in a form of professional development referred to as a "community of practice" (p. 1091). Three cases of teachers were presented to illustrate the types of changes that were typical of the teachers. Overall, Akerson et al. found teachers' views of NOS improved, but they taught NOS in a variety of ways, demonstrating the complex relationship between knowledge and practice and how tightly some teachers hold to their original beliefs. The formation of a community offered teachers a variety of outlets for help and supported some teachers as they learned how to implement NOS. A community of practice by its very nature provides teachers with a wide variety of supports that extend beyond the professional development setting, which makes it difficult to ascertain that any growth is a direct result of the professional development. The authors acknowledge this however, and see potential for impact from this type of professional development.

These studies demonstrate that teachers often have two sets of beliefs, those they exhibit in the classroom and those they state but never follow through on in the classroom (Keys, 2005). In order to understand how a teacher's beliefs may be impacted by participation in a study group, it is important not only to hear what teachers believe, but

to also confirm this by observing their practice. Many teachers need ongoing support as they attempt to implement a new practice that may not be aligned with their beliefs. Stoffels (2005) and Pekmez et al. (2005) point to the fact that new programs are often overwhelming to teachers and end up being implemented in a mechanical manner, which can be detrimental to reform-based efforts. However, when teachers are ready for change and have ongoing support in some form they can move reform-based efforts forward (Peers et al., 2003; Pekmez et al., 2005). Researchers need to explore the different supports teachers require to help them as they change their beliefs and implement new ideas related to reform-based efforts, such as writing in science. My study is designed to address these limitations by exploring how teachers' beliefs and practices, related to the reform-based practice of writing in science, were impacted by their participation in a study group as a form of on-going professional development.

Collaboration as a Form of Professional Development

To understand teacher collaboration as a form of professional development, a review of the literature was conducted. I searched three databases using the terms "lesson study," "community of practice," "community based" and "professional development." The databases included Professional Development Collection, ERIC, and Education Full Text. These searches resulted in over 200 articles, of which there was some overlap. Several articles were eliminated due to their focus on unrelated topics. Finally, a review of selected articles' references was used to determine other studies that related to the topic. This resulted in four articles that met the criteria of being empirical and focused primarily on teachers engaged in collaboration as a form of professional development.

The literature on professional development states that effective professional development should be ongoing; should provide teachers with opportunities to collaborate and practice new ideas; and should focus on issues of instruction and curriculum (Wilson & Berne, 1999). It is also beneficial to ground professional development in the context of students and learning and to establish a community that can help support the learning process (Ball & Cohen, 1999; Wilson & Berne, 1999). Professional development for teachers typically consists of workshops, either episodic or over time, in which teachers are introduced to a new idea and materials with which to implement it (Ladson-Billings, 1999). However, such professional development can take a great deal of time and money. Fullan (2007) refers to this type of professional development as "ineffective and wasteful" (p. 15). When teachers participate in these more traditional workshops, practice is typically impacted after 80-100 hours (Levitt, 2002; Supovitz & Turner, 2000) and classroom culture after 160 hours (Supovitz & Turner, 2000). While change is promising, districts, schools, and teachers do not have the time or money to allocate to learning in this way. This is especially true for science, which is often cut short due to the demands placed on literacy and mathematics as part of No Child Left Behind (Marx & Harris, 2006).

In contrast to the traditional workshop, some scholars call for an improvement to teaching and learning through collaboration amongst teachers (Cochran-Smith & Lytle, 1992; Fullan, 2007). Collaboration as a form of professional development has been demonstrated through lesson study (Fernandez, 2005; Oshima et al., 2006; Parks, 2008), communities of practice (Levine & Marcus, 2010; Lieberman & Pointer Mace, 2009), and professional learning communities (Hollins, McIntyre, DeBose, Hollins, & Towner,

2004; Louis & Marks, 1998; Strahan, 2003). Vescio, Ross, and Adams (2008) reviewed the literature on professional learning communities and the impact they have on teacher practice and student learning. Based on 11 studies, they concluded that learning communities impact teachers' practice, in that teachers have a greater focus on student centered learning, causing students to benefit as well.

Much of the research on lesson study showed that it influenced teacher's knowledge and beliefs as it pertains to subject matter knowledge, pedagogy, or student thinking. Fernandez (2005) examined a team of four teachers as they conducted a lesson study on fractions to determine the extent to which teachers took advantage of lesson study as an opportunity to learn and how it impacted their mathematical understandings. Analysis of field notes and videotape from meetings, artifacts, and video of lessons showed that teachers developed new knowledge about pedagogical content and how to reason mathematically; however, she stated that lesson study was simply a process and the amount learned depended on what the teachers brought with them to the discussions and that some would benefit from having a "teacher of teachers" (p. 284) as part of the team.

Other studies also found that modified versions of lesson study resulted in development of teacher knowledge in some aspect. Oshima et al. (2006) analyzed video of lessons and meetings, interviews, and reports from the teacher on classroom teaching for one case in the area of science. They concluded that a modified lesson study increased different aspects of teachers' science knowledge. Parks (2008) analyzed class discussions and focal group conversations from her college level course and found that some groups developed the ability to look at a math lesson through a mathematical lens as a result of participating in a lesson study assignment.

Finally, Levine and Marcus (2010) studied how different types of activities within a collaborative group improved teacher and student learning in one high school. Six teachers and one principal were involved in the study. Based on observations of the meetings and interviews the authors determined that the structure and focus of the activity ultimately affected the opportunities to learn through collaboration. They concluded that for collaborative work to be most effective it should be structured and focused on a specific topic of importance to the teachers.

The studies presented in this section make the case that teachers who participate in collaborative groups gain knowledge (Fernandez, 2005; Oshima et al., 2006; Parks, 2008); however, in order to do that the meetings need to be structured and have a specific focus (Levine & Marcus, 2010). Very little of this work has been done in the area of science and none related to writing in science. Since small collaborative groups have demonstrated their power to help teachers learn in other subjects, it is important to understand the impact it may have on teachers' practices and beliefs related to writing in science. This study addressed this problem by exploring how teachers utilized a study group as a means of building community focused on the implementation of notebooks and the use of write-to-learn strategies. This allowed me to understand how teachers develop these ideas within a social setting and then how they take information back to their classrooms and support students in the development of the language of science.

CHAPTER 3

METHODOLOGY

In this section, I justify the research method that was used to explore this study. Following this, I explain and justify the parameters of the study using this methodology, including the context, participants, data sources, collection methods, and analysis.

Research Method

Teachers do not have a clear sense of how science notebooks should be implemented to help students develop scientific understanding, nor have they had professional development on this topic. The central issue of this study is how teachers' beliefs and practices, related to science notebooks, and in turn their students' performance, are impacted when they participate in a study group as a form of professional development. This type of issue can be understood best by examining the experiences of teachers who participate in this type of professional development as well as their student's work. Such examination is descriptive in nature, making qualitative research and case study methodology very appropriate for this research.

Creswell (2007) defines a case study as "the study of an issue explored through one or more cases within a bounded system" (p. 73). Both Merriam (2002) and Creswell define a case as a bounded system, which may be bounded by time, space, or components and has a defined starting and finish point. For this study, the bounded system was the group of teachers, including their work in the study group, their classrooms, and their students' work in the given time frame of January 2011 through June 2011. The components of the bounded system were examined to better understand how science notebooks are being used in the context of a primary classroom.

In this study, I explored the impact professional development had on teachers and in turn the work produced by students in the classroom of these teachers. While I could have studied the context of the professional development setting or the culture the teachers created within their classrooms, neither of these would have allowed me to really understand the impact this type of professional development may have had on the teachers' beliefs and practices as well as student outcomes. To fully understand this, I needed to study in depth the individual teachers, including their participation in the PD, their classrooms, and their students' work, as the unit of analysis (Merriam, 2002) rather than just the topic being investigated. By focusing on the teachers I was able to describe in depth how their understandings and facilitation of writing within science notebooks was impacted by the professional development as well as the impact it had on their students' learning. This idea also aligns with other definitions of case study in the current literature (Bogdan & Biklen, 2007; Yin, 2009).

Following the advice of Yin (2009), I conducted a multiple-case study, which Bogdan and Biklen (2007) define as "[w]hen researchers study two or more subjects" (p. 69). Since describing several classrooms in depth could quickly become overwhelming, I studied the classrooms of three teachers' who participated in the study group; further details of these participants will be shared later. This offered a perspective of what teachers' beliefs and practices and students' notebooks look like at different stages of participation. By following three teachers, my study is regarded as more robust (Herriott & Firestone, 1983). Furthermore, it provides what Yin refers to as *analytic benefit*, as similar conclusions from different cases are more powerful than those from a single case. In addition, the three cases allowed for a cross-case analysis (Creswell, 2007), which led

to the development of a substantive theory (Merriam, 2002), on the development of insightful implementation of science notebooks. A "substantive theory is localized, dealing with particular real-world situations" (Merriam, 2002, p. 7) and emerges from the data.

Context

This case study examined three primary classrooms in an urban elementary school in the Southwest region of the United States. This school is in a low socio-economic area, with 92% of the students receiving free or reduced-cost lunch. The majority of the students at the school are Hispanic (89.0%) followed by White (5.2%) and African American (4.9%). Language development is a concern for the school with 82% of the students being classified as having Limited English Proficiency. The school opened in 2005 as an inquiry-based science school. As an inquiry-based science school, all teachers are required to teach science on a daily basis in a manner that is consistent with reform-based practices, including writing in science. Teachers use the *Full Option Science System (FOSS)* (Lawrence Hall of Science, 2005) program as the main science curriculum. In the *FOSS* curriculum, students explore the natural world through guided inquiry. The hands-on experiences they participate in allow them to learn scientific concepts, develop critical thinking abilities, and construct ideas through their own investigations and analyses. In addition, teachers at this school are expected to incorporate science notebooks within their science lessons and have a full-time science mentor on staff.

Based on the principal's strong belief that writing in science is beneficial for learning in all areas, all students utilize science notebooks as an integral part of their learning

process. However, the teachers were concerned that they were not facilitating notebooks in a manner that allowed children to benefit the most. Based on this concern, a study group was established that met once a month to examine notebooks and discuss strategies to help facilitate student learning. Some of the members of this study group have served as participants of a pilot study for this research. This pilot study helped determine that a study group can help teachers develop their beliefs about notebooks and learn how to facilitate write-to-learn strategies within the science notebook. This led me to examine participants who had been in the group for different amounts of time to understand how their participation over time impacted their beliefs and practices.

Site Selection

This site was selected for several reasons. First, as a teacher within the building and the facilitator of the study group, I have access to the site and the support of the principal and teachers; both of these are important elements according to Bogdan and Biklen (2007) and Marshall and Rossman (2006). Second, all classes use science notebooks as a component of their science lessons and all teachers have access to professional development on science notebooks, which I provide as the site's science mentor. Finally, the study group was founded out of teacher interest and serves as an ongoing form of professional development to which all teachers have access. As the science mentor, I participate in the study group and help to facilitate discussions, acting as a "teacher of teachers" (Fernandez, 2005, p. 284).

The Role of Participant Observer

As the science mentor in the building, it is my responsibility to provide professional development for teachers, of which the science notebook study group is an ongoing

professional development opportunity. I participate in the monthly study group meetings, and based on teachers' interests, provide them with resources to help them move towards their stated goal. As a mentor, I have attempted to put together an innovative design that should bring about change, and now studied that innovation as a participant observer (Creswell, 2007) and researcher.

Qualitative research takes place in naturalistic settings and it is important that the researcher spends time within that setting in order to develop a true understanding of its components (Bogdan & Biklen 2007). As a staff member at the school in which the research took place, I was intimate with the environment and most of what happened within it. However, this study allowed me to examine the issue of writing in science more closely. As a participant observer, it was important for me to be aware of the benefits and drawbacks associated with it. Yin (2009) discusses specific benefits, including: (a) daily interaction with the participants, which may provide insights into their behaviors; (b) easy access to the classrooms and meetings; (c) an inside perspective which may help produce a more accurate description of the case; and (d) the ability to manipulate meetings and such to which I would not otherwise have access. Along with the benefits, Yin also describes some serious drawbacks including: (a) bias, (b) support for the group that is being observed, (c) conflict between the roles and responsibilities of a researcher and a participant, and (d) management of time for each role. In my opinion, the benefits outweighed the drawbacks; however, I needed to be cognizant of my biases and support for the group. In order to balance out my role as a participant observer, I attempted to mediate my bias by acknowledging my role from the onset, triangulating the data, and conducting a member check to ensure validity of my interpretations.

Participants

Both Creswell (2007) and Yin (2009) state that the selection of participants is an important step. While Creswell (2007) describes it as purposeful sampling, Yin (2009) states that the selection of candidates should be based on operational criteria. The operating criteria for this study consisted of three factors (a) candidates had to teach at the primary level, (b) candidates had to be from one grade level, and (c) candidates had to participate in the study group. Members of the study group were invited to participate in the study. A "purposeful sampling" (Creswell, 2007, p. 125) of participants was conducted. The operating criteria narrowed the potential candidates down to those who taught first or second grade, as no kindergarten teachers participated in the study group.

Next, Yin states that the researcher should screen the candidates by collecting relevant data on them to ensure the cases are viable. As a teacher in the building, I was aware of the background of different teachers and this helped in selecting candidates who had similar backgrounds, interest in science notebooks, and participated in the study group over different amounts of time. Based on this process of purposeful sampling, three teachers were selected, and the classrooms of these teachers served as the cases for this study.

Study group participants.

Twelve teachers from the school signed up to participate in the study group during the 2010-2011 school year. These study group participants, including the three cases in this study, took part in the four study group sessions that were videotaped for this study. Three of them taught first grade, five taught second grade, one taught third grade, two taught fifth grade, and one taught special education. Two people had been members of

the group since 2007, two joined in 2008, two were members since 2009, and six joined in 2010.

The teaching experience of the group ranged from 2-31 years, with the mode of experience being six years. Most joined the study group in order to learn more about science notebooks and how to implement them in their classrooms. The diversity of this group and their experiences added to the discussions in the study group, and allowed me to consider the impact the study group may have had on teachers' beliefs and practices over different amounts of time

The three cases.

Megan (all teachers referred to by pseudonyms) is a white female and second grade teacher in her sixth year of teaching. She graduated from a traditional teacher education program at a private university located in the Midwestern United States. She has a bachelor's degree in elementary education. She was hired at the school out of college and was a member of the inaugural staff. Megan has utilized science notebooks in her classroom throughout her teaching career and has participated in extensive professional development focused on science notebooks. She joined the study group in the spring of 2007 when it was formed.

Elizabeth is a white female and second grade teacher in her eighth year of teaching. She attended a traditional teacher education program at a large Western university. She has a bachelor's degree in liberal arts and a master's degree in literacy. She was hired as part of the inaugural staff and has an interest in science. Elizabeth has utilized science notebooks since coming to this school and joined the study group in the fall of 2009.

Annie is a white female and second grade teacher in her eleventh year of teaching. Her first degree was a bachelor's in communication and she worked for several years in retail management. She returned to school, attending a large university in the Southwest United States and earned a second bachelor's degree in elementary education as part of a traditional teacher education program, and then went on to pursue a master's in elementary education as well. Annie chose to be part of the inaugural staff of this school. The majority of Annie's teaching experience was in first grade. She had taught second grade during her second year of teaching, but returned to first grade after that. In 2010-2011 she returned to second grade, looping with the first graders she had taught the previous year. While she is a strong teacher, she does not feel that science is her best subject, but she teaches it regularly and enjoys it. She joined the study group in the fall of 2010.

These three participants were purposefully selected, as they fit the operational criteria (Yin, 2009) and provide a sense of the impact the study group may have over time on a teacher's beliefs and practices.

Students from the cases' classrooms.

Students from each classroom also participated within this study, as I examined their science notebooks and tests to determine how the teachers' practice influenced their use of the notebook and understandings of science. Eighteen students from each of the three classrooms participated in the study for a total of 54 students. Three students from each of the classes, for a total of nine students, were selected, with help from the teachers, based on a purposeful sampling that represented the classroom demographics and student

abilities, which will be described below. These nine students provided further insight into the children's conceptual understandings of science and use of the science notebook.

The student participants were typical of the students in each of these classrooms, as all were Hispanic, received free lunch, and were classified as Limited English Proficient at one point in their schooling, based on reports from April 2011. Students are represented in this paper by the teacher's first initial and a number of one, two, or three. Based on the teachers' selections, it happened that all ones and threes were girls and all twos were boys. A one indicates a student who was considered by the teacher to be lower in both her understanding of the scientific content and her writing ability. A two indicates a student who was considered by the teacher to be higher in his understanding of the scientific content but lower in his writing ability. A three indicates a student who was considered to be high in both her understanding of the scientific content and her writing ability.

Teachers were unable to identify any students they thought were low in their understanding of the scientific content but high in their writing ability. The rest of the students from each class were assigned pseudonyms using the teacher's first initial and the numbers 4-18. The students allowed me to examine the impact the teachers' beliefs and practices were having on the students' performance, in terms of their understanding of the science content and use of a science notebook.

Data and Analysis

A variety of data were collected and analyzed to address my research questions: (a) How are teachers' beliefs and practices, as they relate to the use of science notebooks and write-to-learn strategies, impacted by participation in a study group focused on science

notebooks? and (b) How do these beliefs and practices influence student performance in terms of notebook development and understanding of scientific concepts? Since this study looked at the relationships between professional development, a teacher's beliefs and practices, and student learning, I created a visual representation (Figure 1) of how these factors work together and the types of data that were needed to examine these relationships. The types of data that were collected and the means for analysis are specified in my methodology table (see Appendix A) and will be described in detail below.

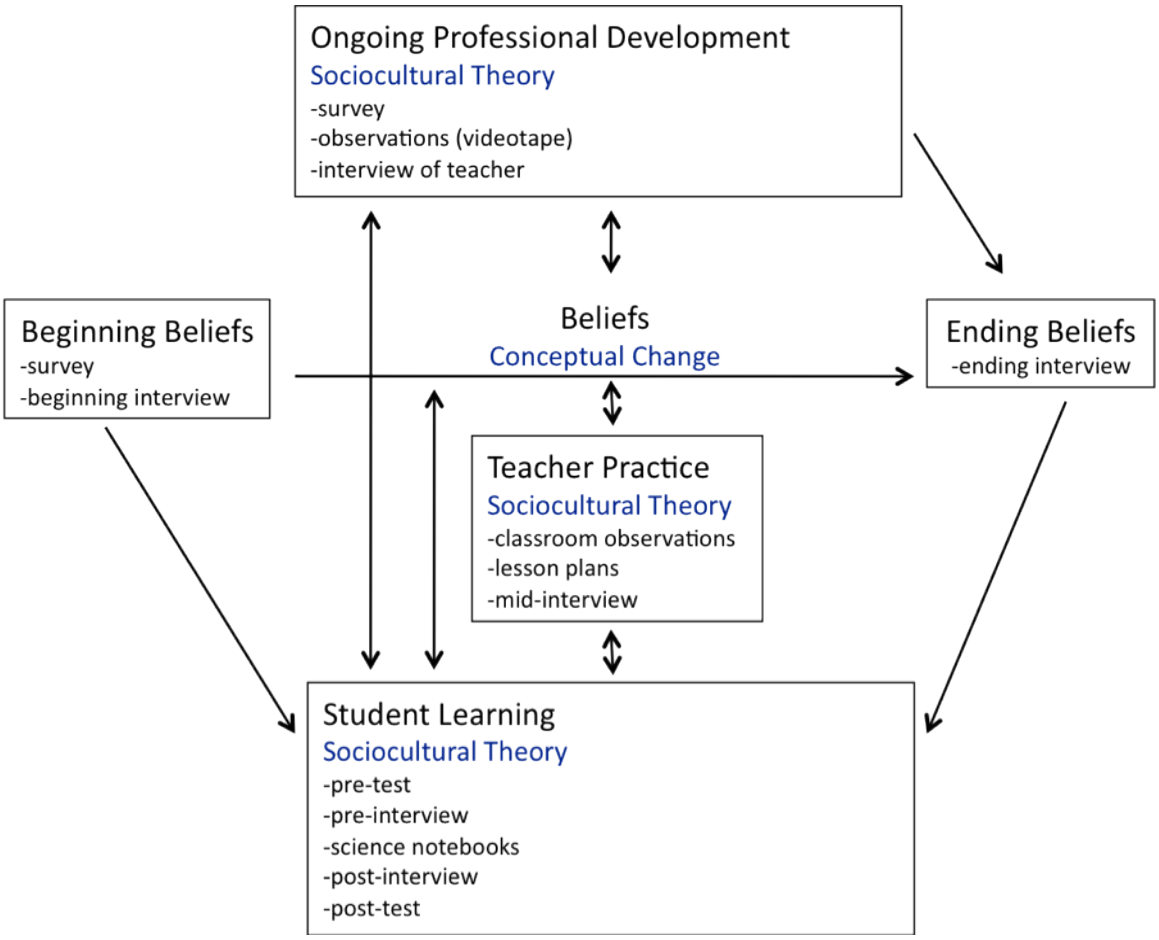

Figure 1. Relationships between Professional Development, Beliefs, Practices, and Student Outcomes.

Data

In qualitative research data are all around, "ordinary events become data when approached with a particular frame of mind" (Bogdan & Biklen, 2007). Data serve as both evidence and clues for the researcher to answer the questions posed. In this study, data collection began in January 2011 and continued through June 2011 and is outlined in a timeline of the study (see Appendix B). Merriam (2002) states there are three main types of data, including "interviews, observations, and documents" (p. 12). Yin (2009) states that another type of interview, those with "more structured questions, along the lines of a formal survey" (p.108), may also be used in a case study. This study used all four types, which will be described below.

Interviews.

Yin (2009) states that interviews are an extremely important source of data in a case study and describes them as "guided conversations." Merriam (2002) refers to this kind of questioning as semistructured interviews, where predetermined questions guide the interview but wording and order are not as important. These are the types of interviews I conducted; as they allowed me to collect the same type of information from each participant, yet left the interviews open enough for me to pursue an idea that a participant may have raised in answering a predetermined question.

Three interviews (see Appendix C) were conducted and averaged around 30 minutes each. The first was conducted in February, prior to the beginning of the unit on solids and liquids and focused on the teacher's beliefs about writing in science and science notebooks. These interviews were transcribed and coded, to determine questions asked in follow-up interviews midway through and again at the end. A second interview was

conducted in early May, midway through the unit and the third interview was conducted in June, at the end of the unit. The focus of these interviews was on the unit they were teaching and factors that may have been influencing their practice.

The interviews gave me insight into the teacher's beliefs about the purpose of writing in science and science notebooks and helped me determine what factors might influence any conceptual change they may experience with notebooks. The literature on beliefs (Akerson, Cullen, & Hanson, 2009; Keys, 2005; Peers, Diezmann, & Watters, 2003; Pekmez, Johnson, & Gott, 2005; Stoffels, 2005) demonstrates that teachers' beliefs are confronted when they are asked to implement something new and that support is an essential component to help bring about change. For many using science notebooks as a write-to-learn tool is new and the study group serves as a form of support as they learn what this is about and how to implement it within their classrooms.

I interviewed teachers to understand the beliefs with which they entered the study group, how those beliefs changed along the way, and the beliefs they held at the end. The interviews also gave me insight into the teachers' understandings of the unit and how they were teaching it to their students. The teachers utilized the *FOSS Solids and Liquids* (Lawrence Hall of Science, 2005) curriculum for this unit and determined that by the end students should be able to describe differences between the properties of solids and liquids. The big ideas that teachers expected students to walk away with was that solids have a definite shape and maintain their shape as they are moved, and that liquids do not have a definite shape but take the shape of the container they are in.

In addition to interviewing the teachers, I also conducted two interviews (see Appendix D) with three students from each class regarding their understanding of the

properties of solids and liquids, specifically the big ideas mentioned above, and the purpose of a science notebook. As young students, they may struggle to convey some of their thinking in writing (Warwick et al., 1999). The first interview took place near the beginning of the unit, in March 2011, and the second interview took place at the end of the unit, in June 2011. One student was not in school during the last two weeks and therefore was not interviewed a second time. Interviewing them gave me further insight into their conceptual understanding and the degree to which classroom experiences may have impacted this understanding. I also asked questions concerning the purpose of using a science notebook. This allowed me to consider how the classroom culture influenced their understanding of the notebook and how they use it as a tool to facilitate their learning.

Survey.

A Likert scale survey (see Appendix E) was given to all members of the study group in March 2011. Ten of the 12 participants completed and returned the survey. This survey allowed me to gain insights into the participants' beliefs about science notebooks and the role writing plays in science as well as some background information, which could be used to support findings from the interviews and compare teachers' beliefs based on the number of years they participated in the study group.

Observations.

Data were also collected in the form of observations. These observations serve as "a firsthand encounter with the phenomenon" (Merriam, 2002, p. 13). Many times teachers' belief systems are very strong and while they may understand reform-based practices and believe they are implementing them, their actions may be very different. It is important

as a researcher to collect first-hand data to determine if espoused beliefs and actions match what is actually happening in the classroom.

Teachers were asked to place a video camera in the back of the classroom and videotape all lessons pertaining to the *FOSS Solids and Liquids* investigation on "Bits and Pieces" (Lawrence Hall of Science, 2005). The number of lessons videotaped ranged from three in one classroom to seven in another classroom. In the *Solids and Liquids* module, students learned that objects have observable properties that can be used to describe the objects and group them. In addition, they learned that materials exist in different states – solid, liquid, and gas. In the first investigation, students studied the properties of solids by describing them, sorting them, and constructing with them. Then, in the second investigation, students studied the properties of liquids by exploring liquids in bottles, describing them, and then observing the liquids as they put them into different containers. In the third investigation, "Bits and Pieces," students explored small particles, such as rice, beans, and cornmeal.

The first part of this investigation had students pouring the materials into various containers, to determine if these materials were solids or liquids. In the second part, students explored the idea that solids can be separated, using screens to separate a mixture of the five solid materials. Finally, in the third part, students considered the similarities and differences between these solids and liquids as they explored how the solid particles behaved when put in bottles. While there was another part in this investigation, it was not examined, as two classes were unable to do it due to time constraints. These observations allowed me to see what teachers actually did in their classrooms to determine if it matched what they said in the interviews and on the survey.

In order to reflect on how the professional development may be impacting the teachers' beliefs and practices, I collected data on what happened in the study group sessions in the form of field notes and video of the meetings. As the facilitator of the study group, I served as a participant-observer (Creswell, 2007) in these meetings. Four meetings were held during this study, one each in January-March and in May. The experiences the teachers had within the group and the level to which they participated influence the ideas they take away from the group, according to Lave and Wenger (1991). To capture these meetings, they were videotaped to ensure that vital information was not missed and they were documented in field notes that were both descriptive and reflective (Bogdan & Biklen, 2007). Since the study group had been in place since 2007, I also used notes that I had taken during those meetings to help reconstruct the history of the group.

Documents.

The final pieces of data were collected in the form of documents. The students' science notebooks should be considered as personal documents in which the students recorded their scientific understandings. A total of 54 notebooks were collected at the end of the unit, 18 from each teacher, and pertinent entries were marked. Entries from the videotaped lessons for the investigation, *Bits and Pieces* from the *FOSS Solids and Liquids* module (Lawrence Hall of Science, 2005) were marked for all students.

By examining these entries, I was able to consider how students were making sense of the strategies the teachers were presenting in the classroom, and how well they understood the scientific concepts. Additional entries, from the three students interviewed from each classroom, were also marked. Based on the idea that notebooks

can serve as a reflection of what was done in class (Ruiz-Primo et al., 2010), the first ten entries from each of the main units of study – insects, air and weather, and solids and liquids – were marked for the identified students.

Entries were labeled with a B 1-10, M 1-10 or E 1-10, with B standing for a beginning of the year entry, M for a middle of the year entry, and E for an end of the year entry. The numbers 1-10 were used to differentiate each entry. This allowed me to reflect on what the teacher may have been doing at the beginning and middle of the year compared to the present lessons. By examining entries throughout the year, I was able to gain an idea of where students started and where they were currently in their abilities to document their scientific thinking.

Along with students' notebooks, I also collected students' pre and posttests (see Appendix F) related to the science concepts they were studying. The same tests, a performance assessment and a written assessment, were used for both the pre- and posttest. In the performance assessment, students were provided with an object (crayon, soil, and lotion) in a container and asked to identify if it was a solid or a liquid and provide evidence to explain their thinking. On the written assessment, students were asked to identify the difference between a solid and a liquid as well as provide an example of a solid and a liquid. Students took the pretest prior to starting the unit and the posttest at the end of the unit. In Annie's class, 16 students took the pretests and 17 students took the posttests. In Elizabeth's class 18 students took the pretests and 17 students took the posttests. In Megan's class 17 students took the pretests and 18 students took the posttests. Both the notebooks and the tests allowed me to corroborate

the information collected from the other sources, as well as examine student practices and outcomes.

Together the interviews, observations, and documents provided a broad and accurate picture of teachers' beliefs and practices related to science notebooks. They also allowed me to determine what ideas teachers were taking from the study group and implementing within their classrooms.

Yin (2009) cautions that three principles to data collection should be followed to ensure reliability and validity of the study. This first principle is to "use multiple sources of evidence" (p. 114). This was met within this study through the use of interviews, observations, and documents. These different sources allowed for triangulation of the data, which helped to strengthen the study. The second principle is to create a database for the case study. A database is a systematic storage of all materials collected throughout the study, such as notes, transcripts, and documents. They should be stored in such a way that others can access them and inspect them. Such a database makes a case study more reliable.

In most instances, data were stored on a computer in files related to each case. Since Yin cautions against spending too much time creating electronic copies of all of the data, student work and any other physical documents were stored as hard copies in files related to the cases. Pertinent student work was scanned in and stored electronically as well. The third principle is to "maintain a chain of evidence" (p. 122). A chain of evidence allows an outside observer to copy the steps of the research process from question to report or vice versa. Again, this principle helps to increase the reliability of the study.

To create a chain, I was cognizant of articulating and documenting my steps throughout the study, keeping an electronic record of this process.

Data collection and analysis are not separate steps within the research process. Creswell (2007) and Merriam (2002) describe the collection of data and the analysis of it as occurring at the same time, allowing the researcher to adjust data collection throughout the process. I followed this procedure as well, and adjusted interviews and other data collection methods as I went.

Data Analysis

One of the most difficult parts of qualitative research can be the analysis of data (Creswell, 2007; Yin, 2009). Bogdan and Biklen (2007) describe analysis as "working with the data, organizing them, breaking them into manageable units, coding them, synthesizing them, and searching for patterns" (p. 159). In qualitative research a great deal of information is collected, and it is important to organize the data and to have "a sense of the whole database" (Creswell, 2007, p. 150). Researchers can do this by reading through transcripts and examining the data, making notes in the margin, before beginning to break it apart. From there the researcher begins to develop themes and detailed descriptions based on what she sees.

In case studies, description is a central component to analysis (Creswell, 2007). These basic procedures served as the beginning of my analysis process; however, I also used specific strategies, such as open coding, content analysis, taxonomic analysis, and event mapping as well. In this section, I examine how each of these strategies was used to analyze the data sources previously discussed within each question. This information

is also referenced on the Methodology Table (see Appendix A). Finally, I will explain how the cases themselves will be examined.

Question one.

To answer the first question, "How are teachers' beliefs and practices, as they relate to the use of science notebooks and write-to-learn strategies, impacted by participation in a study group focused on science notebooks?" I did the following steps of analysis guided by the two theoretical frameworks.

First, I used open coding as a means of analyzing the teacher interview transcripts in order to better understand the types of beliefs teachers espoused and how they may have changed from the beginning of their participation in the study group until the end of this study. This allowed me to note patterns and ideas, which were eventually combined into themes, which included such things as: affective factors, beliefs, challenges, goals, notebooks, and strategies.

Open coding was also used to analyze the video transcripts from the study group in order to examine how the teachers participated in the study group and what they may have learned from being a part of the group. In addition, open coding was used to analyze the transcripts of the classroom lessons in order to link the beliefs they espoused to those they put in practice and to link practices to ideas they learned in the study group. Themes included such things as: collaboration, content, instruction, purpose, scaffolding, and science knowledge. All of the above codes were counted to give an idea of how frequently they occurred in the database.

Second, I used descriptive analysis as a means of analyzing the survey data to describe the three cases' beliefs about science notebooks, because it allowed me to

summarize and describe the numerical data from the survey. This method was chosen due to the fact that survey data were collected from 10 of the study group members, making the sample size too small to be statistically significant (Hinkle, Wiersma, & Jurs, 2003).

Third, I used event mapping (Green & Dixon, 1993; Putney, 2007; Santa Barbara Classroom Discourse Group, 1992) to analyze the transcripts from the video of the study group to examine the focus of the study group discussions in order to understand what ideas the teachers may have taken from the study group. Classroom lessons were also analyzed using event mapping to examine the focus of teachers' practice in order to understand how their beliefs may have impacted their practice. This strategy, which Miles and Huberman (1994) refer to as event listing, embodies the flow of the event as well as the interactions that take place among members of the community. Event mapping showed different levels of events, from the main events that took place within a designated time to subevents and even phases of the subevent.

Question two.

The second question, "How do these beliefs and practices influence student performance in terms of notebook development and understanding of scientific concepts?" utilizes the theoretical framework of sociocultural theory. Sociocultural theory states that change is social and that we learn through our interactions with others. The culture of the classroom and the teachers' beliefs influence the way in which the students view the purpose of the notebook and utilize it as a learning tool. In order to understand these experiences and determine the extent to which they may influence student performance, I did the following steps of analysis.

First, I conducted open coding of the transcripts of the students' interviews in order to compare their verbal explanations of the science concepts they learned to their written explanations. The interviews also illuminated students' understandings of the purpose of science notebooks and how to use them as a learning tool rather than just as a recording tool. Themes included such things as: notebook elements, science content, ways of recording, and why record. These codes were counted to give an idea of how frequently they occurred in the database. In addition, the open coding of the classroom lessons provided insight into how the social aspect of the classroom helped students learn both the scientific concepts as well as the process of writing in science and the purpose of the science notebook.

Second, I used content analysis on the students' science notebook entries to learn more about students' recording strategies and level of thinking present within the entry (see Appendix G). Content analysis, or the process of applying an objective coding scheme, was used to identify characteristics based on a set of rules (Berg, 2001), which helped me to determine how the teacher's beliefs may have influenced the students' notebook entries. The criteria can focus on both manifest content, which in this case would be the type of science notebook entry and characteristics of the entry, as well as latent content, which would be whether the entry was conceptual or procedural in nature.

To establish the rules for the content analysis, I looked to the literature. The literature (Aschbacher & Alonzo, 2006; Campbell & Fulton, 2003; Ruiz-Primo et al., 2004) describes notebooks as a record of what children do during science and states the entries often include such things as words, pictures, and graphic organizers to represent observations, predictions, reflections, and more. Furthermore, Ruiz-Primo et al. (2010)

state that students should include evidence of their thinking in relationship to explanations. This information was used along with an inductive approach to establish a coding frame.

A "criteria of selection" was established (Berg, 2001), consisting of a list of common elements that might be expected in a primary student's notebook. This list included (a) basic conventions of the notebook, such as a date or title; (b) ways in which the information was recorded, such as drawings, words, or graphic organizers; (c) elements of an entry, such as vocabulary and materials; (d) focus of the entries, such as content, activity, or feelings; and (e) level of understanding related to claims, evidence, and explanations.

Content analysis was also used to analyze the students' pre- and posttests. Analyzing the pre- and posttests in this way provided insight into the students' understandings of the scientific content and allowed me to compare this understanding to what they had in their notebooks as well as what the nine were able to tell me verbally. A scoring guide (see Appendix H) was created for each question based on the *FOSS Solids and Liquids* manual (Lawrence Hall of Science, 2005) and the big ideas that solids have a definite shape and maintain their shape, and that liquids do not have a definite shape but take the shape of the container they are in.

Third, I conducted a domain analysis of the students' notebook entries to understand the characteristics of them. A domain analysis looks at the semantic relationships among terms (Coffey & Atkinson, 1996). Using information from the content analysis, domains (see Appendix I) were created based on the relationship of attribution as defined by Spradley (1980). The domain of attribution looked at characteristics of science notebook

entries and contained such things as: feelings, activity, observations, science content, and conclusions.

Finally, I conducted a taxonomic analysis of the nine students' notebook entries throughout the year to understand the characteristics of their conclusions (see Appendix J). This entailed pulling quotes from the student's notebook that demonstrated examples of the conclusions to see what patterns emerged.

Individual case and cross case analysis.

After analysis of the data, each case was written up into a report. These reports were given to the appropriate participants for member checking (Creswell, 2007). Once members confirmed that they agreed with the report, a cross-case analysis was conducted to look for patterns between participants. Since I chose to study candidates at different points in their study of notebooks, this provided the opportunity to compare and contrast practices and beliefs between the different cases. Bogdan and Biklen (2007) refer to this type of work as a comparative case study. As part of the comparison between cases, a substantive theory was developed. A "substantive theory is localized, dealing with particular real-world situations" (Merriam, 2002, p. 7) and emerges from the data. In this study, a substantive theory on the development of insightful implementation of science notebooks was created.

Limitations

This study has limitations, which is true of all research, but measures were put in place to minimize them. Case studies have an inherent limitation, in that they cannot be generalized to a broader context. As Yin (2009) stated, looking at multiple cases helped make the study more robust. In addition, multiple data sources were utilized for the

purposes of triangulation, making any findings more convincing (Yin, 2009). In addition, it is important to reflect again on the challenges I face as a participant-observer. To help overcome the challenges of being a participant observer and the possibilities for bias and support of the group being studied, I employed validation strategies. First, I acknowledged my role from the outset within the report. I also used member checking to ensure that the participants agreed with the findings and interpretations. Finally, I enlisted the assistance of a peer to review my research and pose hard questions about my methods and interpretations.

CHAPTER 4

FINDINGS

In this chapter, I describe the events that took place in the four study group meetings and then build a case for each teacher followed by a cross case analysis. Within each case, background on the teacher is provided including her experiences with science, as this is often cited as a factor that affects the way in which science is taught (Davis et al., 2006). Beliefs and practices related to science and science notebooks are explored, including initial beliefs, current beliefs, and the change that took place.

Since science notebook entries should focus on content rather than activity (Ruiz et al., 2010), the teachers' focus for the lessons on a solids and liquids unit of study are considered. Finally, student outcomes, including their understanding of the content presented as well as their use of the science notebook are examined. Pre and post-assessments and science notebook entries pertaining to the specific lessons examined were collected from all students; however, three students from each class were selected for an in-depth analysis of the notebook as well as interviews. Finally, a cross-case analysis is conducted.

Study Group Meetings

In this section, I share some background on the study group to set the stage for the four study group sessions that were videotaped. Those meetings took place January through May; there was no meeting in April, due to spring break. Then, four themes, from the video analysis, are presented. These themes include: the notebook as a tool, the students' struggle to write, the notebook content, and the teacher's role. This section provides the reader with insight into the study group and the types of ideas discussed

during the meetings in order to assist the reader in identifying aspects of the study group that were incorporated into the teachers' beliefs and practices. Examples of meeting discussions are shared as appropriate within the individual cases.

Background

Based on teacher interest and suggestions by the school's science mentor, Jones ES decided to start a study group in which teachers could come together to share science notebooks and discuss strategies for implementation. Once a month teachers met and shared their students' notebooks, asking questions of one another to develop an idea of what the notebooks could look like and how to facilitate this development. In the beginning these discussions were focused on the basic elements of a notebook, such as the date, title, and drawings with labels. After some time, the teachers decided that while the notebooks looked "good" they lacked a focus on conceptual understanding and instead focused more on the activity or what students did during science.

To better understand why there was a focus on activity rather than conceptual understanding, the group decided that they wanted to see notebooks in action, and arranged, in the fall of 2008, to observe science lessons in one another's rooms in order to see how notebooks were being implemented. After observing one another in the classroom, the group read the book *Questions, Claims, and Evidence: The Important Place of Argument in Children's Writing* (Norton-Meier et al., 2008) in the fall of 2009.

At the same time, the group began implementing the Japanese model of lesson study (Hiebert & Stigler, 2000; Lewis, Perry, & Murata, 2006) in which they planned a lesson, implemented/observed the lesson, debriefed the lesson, revised the lesson based on student outcomes, and implemented the lesson again. Lesson study helped the teachers

develop an understanding of how to structure conclusions, or the use of claims, evidence, and explanations, within the science notebook. The focus on conclusions became a school-wide focus in 2009 and all teachers attended a professional development workshop focused on this topic.

During the 2010-2011 school year, the group decided to read and discuss the book *Writing in Science* (Fulwiler, 2007). Based on this book they discussed several strategies they could implement that would help students create more meaningful entries, including: providing students with vocabulary cards at their tables rather than just on a word wall; creating checklists focused on the characteristics of exemplar elements, such as drawings or conclusions; using mini-lessons and shared writing to teach the forms of expository writing expected in the notebook; using a box and T-chart strategy when comparing materials; and assessing science notebooks on a regular basis and providing feedback to the students. During the study group meetings, the 11 participants discussed a variety of strategies, some from their reading and some from their own practice, which could be used to help students learn how to use a notebook (Figure 2).

Sentence frames/starters	Picture prompts
Modeled writing	Important details - highlighting
Think aloud	Team writing
Class notebook	Graphic organizers
Teacher preplans conclusion	Self-assessment
Audiotape response	Focus questions
Examine others' notebooks	Blogs
Feedback on post-its	Comparison of objects
Time to talk as a group	Dictation
Vocabulary cards	

Figure 2. Strategies for enhancing science notebook entries.

Some of these strategies were revisited from previous years' meetings, such as the use of sentence frames/starters, the class notebook, and focus questions; however, others were new, such as the idea of using iPods to have students audiotape their response to a question before writing it out, providing pictures of materials from the teachers' guide to prompt student writing, or asking a group of students to compose a written response as a team. Teachers found these strategies to be important components of the discussion, as they could take them back to the classroom and implement them immediately.

While the discussion of strategies was a main component of the videotaped meetings, there were also themes to the discussions that emerged upon analysis. These four themes: the notebook as a tool, the students' struggle to write, the contents of the notebook, and the teacher's role will be examined next.

The Notebook as a Tool

In order to move the notebook from looking good to focusing on conceptual understanding, the participants believed that students needed to see it and use it as a tool; making it more than a "bound science workbook." As a tool, students should be referring back to information within it, whether that be during a class discussion, on a test, or to create a finished product based on information in the notebook, as demonstrated in this comment from the May meeting,

> They have to know how to use their notebooks, and that's what they do when they go out and do KidBlog. They go out and they use their notebooks to find their information. It's just like when you are answering a question on the CRTs and you read the text and you have to go back into the text to find the answer. It's the same exact thing.

This idea of using the notebook as a tool that students could use as a reference for information was discussed in three of the four meetings for a total of 55 minutes. Ten of

the 12 participants engaged in this discussion, including Elizabeth and Megan. This theme points to the fact that teachers believed that the purpose of the notebook goes beyond simply recording what was done in science, and that students should be able to use it as a tool to help them make sense of the science.

The Students' Struggle to Write

Another theme, the idea that students struggle to get their thoughts down in writing, was discussed in three of the four meetings as well for a total of 20 minutes by seven of the participants, including Elizabeth and Annie. This struggle was characterized by Elizabeth's comment during the January meeting,

> I had a problem today, I was helping a student write, and I was saying, "Okay, how did you know this, tell me more?" And he was able to tell me, but then I walked by five minutes later and he didn't have it written down. So, I don't know if that's just he needs to talk about it more with someone else or, I don't know. I mean because they know it and they can tell it to me, they can tell me more, but to get them to actually write it down is hard to do.

While members discussed strategies to assist students in writing, eventually it came down to a quality versus quantity issue, and members determined that they should focus on quality rather than quantity. While students' writing ability was a real struggle, this led the teachers to question their expectations and what they really wanted to see in the notebooks, focusing more on content than pages of repetitive writing. In the end though, members came to the conclusion that students needed time to be able to talk with one another, to rehearse their ideas, before attempting to capture their thoughts in writing.

The Notebook Content

A third theme, a focus on the content within the notebook, was addressed in all four of the meetings for a total of 95 minutes. Nine participants joined in this discussion,

including Elizabeth, Megan, and Annie. A recurring aspect of this discussion focused on the use of the word "because" and the importance it played in helping students explain their thinking. While the word because seemed to be an important component, teachers noticed that it was not always present in students' entries. To examine what students were doing in entries, participants were asked to look at samples from a fifth grader's notebook and a second grader's notebook. For the fifth grade sample, study group members were provided with two rubrics, Characteristics of an Exemplary Basic Conclusion and Characteristics of an Exemplary Complex Conclusion (Appendix K), based on Fulwiler's work. Using these rubrics they examined the student's conclusion and determined that while it had parts of a conclusion within it, it was not really a conclusion but rather a summary. While a summary is helpful, it conveys what was done in science rather than what was learned. The group came to the conclusion that they needed to work harder to incorporate conclusions into the students' notebooks.

For the second grade samples, the teachers looked at student growth over time. Several pages from a unit of study on air were copied out of one student's notebook. During this time period, the teacher had implemented a new strategy of using pictures from the teacher's manual to help facilitate student writing. Students glued these pictures into their notebooks, labeled them, and wrote about what was happening in the picture based on their own experiences with the materials.

In examining these samples, the group discussed how the student had moved from simply noticing things in the beginning to explaining why things were happening; this student's thoughts were becoming more complete. This led the group to discuss the importance of thinking about the tools/strategies selected to accomplish a goal. In this

situation, they thought providing the pictures was beneficial, where as other times it would be more appropriate to have students draw the picture themselves, such as for naming the parts of an insect. While the strategy may or may not have contributed to the student's growth, the teachers discussed the importance of knowing what students should learn and determining the best way to help students meet this goal.

Based on the discussions around the content of the notebooks, the teachers recognized that while student entries were becoming more focused, there were still many aspects that needed to improve. There was also some discussion about how over time they had shifted their thinking from the notebook as a recording device to the notebook as a thinking tool, and that perhaps their teaching and student work was still catching up to this newer way of thinking, which led them to question how best to facilitate this way of recording.

The Teacher's Role

The teacher and her understanding of the notebook and the scientific content influence how students use their notebooks (Aschbacher & Alonzo, 2006; Ruiz-Primo et al., 2004). It is not surprising then that the role of the teacher and what she needs to know or do to help students successfully use notebooks, emerged as another theme, present in all four of the meetings. Elizabeth, Megan, and Annie joined seven other participants in discussing this topic for a total of 44 minutes. The following excerpt was typical of these discussions.

Megan	I think the kids write it as a personal narrative because they don't have the skills to write it as expository.
Elizabeth	Maybe if you explicitly teach it as an expository writing, and you do like an expository writing mini lesson. Then they do theirs. Then it would be, but otherwise I think you're right it is just a personal narrative.

Teacher 3 You have to explicitly teach the difference. I think that's like the main thing, teaching them what the difference between the two is.

The teachers thought that adding notebooks to their science curriculum would be easy, but found that they struggled with how to do this purposefully and that it took much more time than they expected. They also came to realize that facilitating notebooks, while learning a new science curriculum could be difficult at times, as some of them were learning the content and the flow of the unit. Through the discussions, teachers determined that modeling was an important component of their role, but that they also needed to explicitly teach the skills they wanted students to be able to use. They often compared what they did in literacy to what they did to teach the notebook, pulling ideas directly from their reading and writing lessons, such as think alouds and scaffolding techniques.

Summary of Study Group Meetings

The study group served as a place where the teachers could come together to share their students' notebooks and strategies to develop the notebooks as tools that help students learn science. Throughout the discussions, it was evident that this could be difficult for the teachers and that while they had a sense of what notebooks should look like, they struggled with how to actually get the notebooks to take on the characteristics they envisioned. Elizabeth engaged in discussion on all four themes. It was clear that she was connecting these ideas to her classroom, as will be examined further within her case description. Megan participated in all of the themed discussions except the struggle to write; however, the majority of her contributions related to the notebook content. This was a personal focus for Megan and will be discussed within the description of her case.

Finally, Annie contributed to three of the themed discussions as well, however, her input was on more of a tertiary level, which will be explained further within her case.

Individual Cases

In this section, I build individual cases for each of the teachers involved in the study. First, background on the teacher is provided, followed by a description of her initial beliefs and practices. Next, the influence of the study group is considered, followed by the struggles she encountered in implementing the unit of study. Then current beliefs and practices related to science notebooks are explored. Finally, student outcomes are examined.

Megan

Megan, a white female, has taught second grade utilizing science notebooks as a main component of science for six years at Jones ES, all of which have been in second grade. She has taught the unit on solids and liquids, using science notebooks throughout that time. Megan was hired at Jones Elementary School after graduation, and stated in the initial interview that the vision of science held by the school is the only one she knows besides the way she was taught, which was very different. While she does not have vivid memories of science in elementary school, in the mid interview she described the rest of her science education as "traditional" lecture and being "able to regurgitate and understand why these things were supposedly true."

Initial beliefs and practices.

In this section, I share what Megan remembered about her beliefs and practices when she first came to Jones ES and before she participated in the study group. Her experiences with science throughout her education were very teacher centered, as

described above. She illustrated this further by stating that learning in science was whatever "[came] out of the teacher's mouth was supposed to like stick in your head" (Mid-interview) These are the types of experiences Megan had to draw upon when she entered the elementary classroom for the first time. In the mid-interview, she shared that she felt unprepared to teach science in the beginning of her career, so it was not surprising to hear her describe one of her science lessons during that first year as a very teacher directed lesson.

> So, [my principal] walks in and I am teaching science and I have the overhead on and we were doing insects and I had this paper up and it had, um, blank labels where the parts of the insect needed to be and I had it up on the overhead and basically was asking the kids to tell me where the pieces, or you know the parts of the insect, where the labels should go to identify those parts of the insect. And it was basically, [my principal] was like, "Ohhhh, what are you doing?" Because it wasn't hands-on, it wasn't anything … her jaw dropped.

This lesson reflected the way in which she described being taught, it was teacher directed and focused on delivering information to the students, although she was attempting to involve the students by having them identify the parts of an insect. Based on her conversation with the principal after that lesson, she realized that while she liked science, she was not prepared to teach it in a reform-based manner and needed to seek professional development opportunities in this area, as she stated:

> From that moment on I think I came to this realization that this is not how science is taught. … And, that's where I kind of saw this as well this is a weak point for me and I needed to dive into how do I make it better.

Science notebooks were new to her when she began her career. When she was hired, she was told she would need to use science notebooks, but she was not really sure how to use them. In the initial interview she described her initial introduction to them as: "when I first came, it was like here's a science notebook and here's a book you should read on

science notebooks." Based on this information, she saw notebooks as a reflection piece, where students would write about what they did, as she stated, "Before it was just write, write, write whatever. Okay, cool, they wrote in their science notebooks." In the initial interview, she described how she first introduced science notebooks to her students, "When I first used the science notebook, it was like, 'Here, here's a science notebook. Have fun. Do, write whatever you want.'" In the beginning Megan was new to science notebooks and unsure of how to use them with her second grade students, so she relied on the resource given to her and implemented them in a way that made sense to her based on that resource.

Megan started her career with the idea that science instruction was about delivering information to the students. Based on her principal's belief that writing in science was important, she implemented notebooks. She allowed students to record in any manner they chose and focused their attention on the activity rather than the content. Although Megan's experience with science was teacher-directed and she was unfamiliar with notebooks prior to coming to Jones ES, she recognized she needed to change and sought out learning opportunities.

Influence of the study group.

Megan joined the study group when it first began in 2007. She has participated regularly throughout that time and attended three of the four videotaped meetings during the course of this study. In these meetings, she shared strategies with others, such as using pictures from the science manual to help students record what was happening at a particular moment. She also shared a strategy for helping students analyze an anonymous notebook entry in order to improve their own entries.

She joined the study group in order to learn what others were doing with notebooks and to have a group of people with whom she could converse about notebooks. During the three interviews, Megan discussed several strategies she developed as a result of participating in the study group. One of these strategies was using focus questions to help students write about the concept rather than what they did. Another was helping students utilize the notebook as a tool by incorporating graphic organizers to help organize their information and having them look back at the organized information and use it at a later time.

She was also the only person who implemented the idea of having students use the iPod Touches to record their answer to a focus question and then write it in their science notebooks. In the final interview she reported that she felt use of the iPod had been quite successful, but that it also made her wonder if one day students might keep an electronic notebook rather than a paper copy. Additionally, she also included the strategy of modeling entries at the beginning of the year and keeping a class notebook on the SmartBoard. Finally, she utilized the technique of having students share their science notebooks with a partner, allowing them to support one another's development by seeing and hearing what others put in their notebooks.

While Megan attended the study group to learn, she also pushed others in their thinking about the notebook by posing questions or raising concerns. One example of a time when she pushed others was in asking the question, "Do they need expository writing to get to the scientific ideas or can they get there through narrative writing?" During the May meeting, when others talked about their students' struggle to write and trying to get their students to write more, Megan pushed back a bit with this thought:

> My personal thought is, the science notebooks that I have in my classroom, my kids, I would love to just see the content. And maybe it's three sentences but that's better to me than four pages of a personal narrative. So, like, I see my kids and I see other peoples and I go, "Wow, that's a lot of writing. I really wish my kids would write that much." But then I start reading it and it's like um, I don't know if it's like what we want in our science notebooks, yeah, it's that whole idea quality versus quantity.

This next exchange from the May study group meeting shows how Megan raised a question of how teachers might implement the notebook, to build consistency among and between grade levels, in order to develop the idea that the notebook is a tool and how to use it as such.

Facilitator	We also say that this is a tool to use and as a first grader, … if we are making it too shortened or it is just focusing on bullets, will they understand it when they go back to it? Which is a lot of what I have heard in the past meetings, that this needs to be a focus for us, is using it as a tool and what do we do, how does that look?
Elizabeth	So, are you saying that they should be writing in sentences and not …
…	
Facilitator	Is that something we want to necessarily be doing in first grade?
Teacher 4	You know, sometimes they can't even copy down the sentence starter we've got up there and a lot of what I try to do is to make sure that they can actually read what they've written down so that it does make sense.
Megan	Do you think if you strengthen the skills of the different ways to record information in the science notebook through modeling in the lower grades, then by the time they get to second and third grade, then it becomes now we can focus on, since they know how to record and different ways to record information, now we can use this as a reference tool and we can go back and this is our focus? "Here we are going to focus on, let's get something in the notebook, and let's get it down and organized and these are the different ways you can do it." Then you get to the point of we're now in second grade, we've mastered these skills and we're really good at different ways to organize our information

and we can choose and pick how to do it because it's my notebook, I can choose something different from you to organize it. Now, let's go back and use this as the tool that it's meant to be.

At the meeting in March, teachers focused their discussion on how students incorporated content within their notebooks. After examining several examples, teachers discussed what they were noticing. Again, Megan pushed back with the idea that notebooks should focus on the content and extend beyond students' observations to include evidence.

Elizabeth	I am noticing in a lot of the books that a lot of the kids are using the phrase "I notice." And I'd seen it a lot in my class and I didn't know if it was just my kids that were doing it, but I see that other kids are doing it so…
Annie	We have three prompts, I observed, I noticed, I see and there was another one up on the wall.
Teacher 8	I wonder
Annie	Yeah, and so that's why they always use "I notice" and they write it down.
Teacher 8	I think it's the easiest, it's what you're seeing at the moment, rather than wondering about a question or
Megan	But then they need to, what I notice. Like when they do that, then they don't back that up with any evidence. And I think that is what we need to look at as a group and I know in my classroom I need to do it too. So, when I am demonstrating and doing my science notebook, I'll use one of those and then I'll put the observation and I'll back it up with evidence.

In the three interviews Megan stated that she believed the science notebook study group had impacted what she did in her classroom. Based on her statements, this impact stretched beyond what she did in the classroom to how she believed science notebooks should be implemented. She credited the study group with three main ideas. First, the K-5 nature of the study group had provided her with a vision of what science notebooks

looked like across grade levels, so she had a sense of what she was building off of or working towards when instructing her students. Second, she felt that the group discussions on using the science notebook aligned with her thinking that the notebook is a tool and that students needed to be taught to use it as a reference tool. Third, she talked about the importance of collecting students' science notebooks in order to analyze them more carefully, which she stated was a draw of the study group, as it ensured some time for her to examine her students' notebooks.

Megan realized early on that she had a lot to learn in the area of science if she was going to teach it in the manner her principal expected. In the mid-interview, she described her science education as beginning that first year after the observation and meeting with her principal. "That's when my real education started … being in the classroom, realizing what's expected, and what you want science to look like, and talking with other people who have been around and have knowledge of best practices." She has attended a variety of professional development sessions focused on science and writing in science, including traditional workshops, lesson study, and study groups; she sees all as influencing her classroom practice and beliefs.

> It's not like there's one professional development that has shaped everything that I do in my classroom. That's not how it works. I mean it's growth over time, it's experiencing and listening to what other people have to say and then taking those ideas and taking what you want and molding it into what you believe would fit great into your classroom. (Mid-interview)

While she found professional development to be valuable, and agreed on the survey that she had learned about science notebooks by attending workshops, she strongly agreed with the idea that collaboration around science notebooks was an essential component for her continued development. Based on this evidence, it was apparent that

Megan believed social affective factors were important for her as a learner. The study group met this social need and provided her with the collaboration she needed to grow. It was evident that Megan valued the study group and gained information about science notebooks as a result of her participation.

Struggles.

While professional development and collaboration with others has provided Megan with a great deal of support, she has also encountered struggles. One of her biggest struggles is with ownership of the notebook. She believes that the notebook belongs to the student and questions how much direction she should provide concerning what and how students should record in their notebooks. While she understands that notebooks should represent the scientific content, she questions if notebooks should only contain expository writing, as she describes here in the mid-interview; "but who's to say that a personal narrative isn't useful enough … I mean because if it re-triggers what they've learned and they can tell you the content by just reading that entry …" Her struggle suggests that ultimately she wants the notebooks to be useful tools to her students, even if that does not fit her model of scientific writing.

Beyond the narrative, she is also challenged by the idea that many of her students struggle to write and take a great deal of time to put their ideas down on paper, yet they can verbally articulate the big ideas related to what they are learning. Incorporating the iPod Touches into her teaching during this unit, added to her struggles. While she felt this strategy was helpful, she began to question if notebooks always needed to be written or if students could keep an electronic notebook on an iPad or iPod. With a population that struggles to write, she stated, in the final interview, that time is a major factor in any

decision she makes with the notebook, as incorporating the notebook into science definitely requires time.

Finally, she struggled with the content of the science and coming up with what she called “authentic” writing experiences for the students, as they were exploring the properties of solids and liquids and using graphic organizers to organize their thinking and making lists of properties. While she questioned the amount of writing opportunities that were available in this science unit, she also questioned how much she pushed the content, which she believes is central to the notebook.

Megan’s struggles demonstrate her reflective side. She continues to question her practice and what she currently believes is best for her students. This has led her to question the type of writing her students utilize within their notebooks and the best means for capturing their thinking and how technology might influence the types of notebooks students keep.

Current beliefs and practices.

Megan believes that students are more likely to understand something if they have the opportunity to discover it on their own rather than being told about it. In the mid-interview she stated that she saw science as an important subject for elementary students but especially important for the diverse population with whom she worked to help develop language based on the experiences they had with science in and out of the classroom. She believes that hands-on science is important to help her students learn, and marked on the survey that she strongly agrees with the idea that language and writing are an integral part of science. She places a strong emphasis on values as a mediating factor as to why she teaches science the way she does. In the interviews, she repeatedly stated

that science develops innovators, “people that can think on their own and discover things and question things” (Mid-interview).

Beliefs about science notebooks.

Before Megan saw notebooks as a place for students to reflect on the activity they had done. However, she now believed, as marked on the survey, that notebooks should contain basic elements, observations, and procedures. She strongly agreed with the statement that notebooks should reflect learning rather than what was done in science, and placed a greater emphasis on conclusions using claims, evidence, and explanations. In order to support this Megan stated in the initial interview that it was important for students to record while they were working, and then to go back into the notebook to pull out the important details and summarize information, as she assumes scientists do and as was discussed in the study group. She also believed it was important for students to use their notebooks during “science talk” as a tool while they shared and debated scientific content they had learned in order to really use it as a tool.

In addition to it being a tool for the students, she also saw the notebook as a tool for herself and felt it was essential that she pick up the notebooks on a regular basis in order to really know where her students were in their thinking. This idea was discussed in the study group. In addition, Megan discussed the idea of providing feedback from the perspective of a scientist rather than the teacher, to help students see the importance of recording in a certain manner rather than recording a particular way just to please the teacher. This idea of using the notebooks as a tool for herself is a change from her earlier beliefs, as Megan’s strong belief that science notebooks were the students’, not hers, prevented her from picking up students’ notebooks in the beginning. This same belief

caused her to not model as much as she believes other teachers do. She explained her belief that if students feel as though the notebook is theirs, that it will provide a hook that makes them want to use it more and that they will feel more secure using it. This strong belief presented Megan with a challenge of knowing that she needed to scaffold her students' learning while at the same time ensure that they were making decisions about what was important to record and the best way to record it so that they would understand it later.

Megan's science notebook goals for the FOSS *Solids and Liquids* unit were similar to her beliefs about notebooks. She stated in the mid-interview that if she does not set a goal she realizes she will not see it in her students' notebooks. She discussed three main goals in this area. First, the importance of students using the science notebook as a tool, a resource that they could go back into and find information. Second, she emphasized the importance of students focusing on the content rather than what they did that day. For this, she felt it was important to focus again on claims and evidence, as she did not feel that they would have full conclusions. Third, she stated that some students tended to struggle to get anything into their notebooks and a goal for them would be to help them get something into their notebooks so she had an idea of what they understood. These goals were emphasized throughout her lessons with such statements as:

> Remember the notebook is a tool. It's a tool to help us remember what we did and it's a tool to help us go back and look at things that we wrote down, the ideas that we had. (Lesson, May 25)

> As a scientist you want to write down everything that you learn, big or small because you can always share information. Remember this is a resource so get everything in so that you have it to share and you have it to go back to look at. Because notebooks are very important to scientists, they are important to you. (Lesson, May 26)

Megan's beliefs about science notebooks changed from a focus on activity to content based recordings. While she still believed that science notebooks should be individual to each student, she recognized that she had a responsibility for helping her students learn what to record and how to utilize that information. She shifted her thinking from the notebook as a recording device to the notebook as a learning tool.

Practices.

Megan has strong beliefs about the science notebook and the role it should play in science, and many of these beliefs were evident in her classroom practice. Classroom practice, and hence student learning, are greatly influenced by the teacher and her understanding of what she is teaching (Brophy, 1986; Hill et al., 2005; Ma, 1999; Shulman, 1986). To understand how Megan set up her lessons, I first examine her goals for the scientific content.

In the mid-interview, Megan stated that by the end of this unit she wanted her students to be "able to define a solid and a liquid clearly and confidently with evidence." She went on to clarify that she wanted the students to be able to say that a solid "holds its own shape" and define the differences between a solid and a liquid. This focus on content was present in her lessons as well, with seven references to this goal as she worked with students. In this example of an exchange from the lesson on May 26, a student discussed how he knew that mung beans were solids:

Teacher	Someone said it's a solid. Why do you believe so, give me some evidence?
Student 1	Because it has its own shape.
Teacher	Has its own shape (typed this into class smart notebook). What do you mean by that? Explain to me what you mean by has its own shape. … What does that mean when you

	say that? … Cause if I was someone else and I didn't know what that meant …
Student 1	If you pour a liquid in water, um, the liquid changes to the shape of the bottle and, um, uh, … you um, … you put a solid in and it doesn't change its shape.
Teacher	Put a solid in a … (whispers container)
Student 1	If you put a solid in a container the solid doesn't change its shape.
Teacher	So that's what you mean by the solid doesn't change its shape. Okay.

In this next example from June 1, students discussed the differences between liquids and solids and how they could fit through different sized screens:

Student 2	It's a liquid.
Teacher	What property does, do we know that a liquid has that we know that our bits and pieces and particles aren't able to do?
Student 2	Makes its own shape.
Teacher	Makes its own shape. Right? So it changes, because it doesn't have a shape, that shape can change to fit through lots of different things. If I throw it on the table it is going to get flat and spread out. If I go through the large screen it is going to be able to do that. If I go through the medium-sized screen, if I go through all three of them, if I poured it through all three and it went through all three of them because it doesn't have a defined shape, like cornmeal, or a lima bean. A lima bean has a shape right? And it's not going to be able to go through these because none of these holes are …
Student 3	Big enough
Teacher	Big enough, they're not big enough to support it. But I can get one that's huge and I'd still be able to pour this (liquid) through it. If I get a screen that's really itty-bitty tiny, that may be like flour can go through and I pour this through, what's going to happen to the liquid, it's going to be able to…
Students	Go through. Get in.

Teacher	Go in, right, get in. So, we're, what the idea here is for us to realize that, for us to really realize that, liquids don't have a shape. And we know solids now can be…
Students	Their own shape.

Megan's beliefs that science notebooks were an important component of science were also apparent, as science notebooks were evident in every lesson; students had them with them as they worked on or discussed a topic. Megan also referenced notebooks, in some manner, in all but one of the lessons. Furthermore, Megan supported her students by incorporating a variety of supports and scaffolds that had been discussed in the study group, including such things as a class notebook, graphic organizers, focus questions, and the iPod.

She kept a class notebook via her smart notebook. In this notebook she demonstrated to students how to organize information using a graphic organizer, the tree map, and how to use it as a reference tool to look back at information they had previously recorded. Three focus questions were posed to students to help them focus their writing on the content. Those questions included: "Is cornmeal a solid or a liquid? Explain how you know." "What did you learn about solids today?" and "What do you think would happen if we poured different liquids through the screens?" Incorporating an idea discussed in the study group, Megan utilized the iPods to help her students capture their thinking verbally, which they listened to as they wrote their answer in their science notebooks.

Megan believed that language and her students' ability to communicate in writing impeded their notebook entries, as they were able to verbalize their ideas more easily than they could write them. As a result of discussions in the study group, Megan pointed to the importance of providing students with time to talk in order to support their written communication in the notebook. In the initial interview she stated

> If [students] don't talk with somebody else then a lot of them tend to struggle to get anything in their notebook. … if they don't have anything in their notebook they may still be able to verbally express what they're thinking about and if we have a discussion then they have, they hear what other people are saying. It just helps to support getting something into their notebook.

She employed many strategies that focused on students' verbal skills within her classroom, including science talks, where students sat in a circle and discussed/debated their ideas with one another. Students would bring their science notebooks to this circle in order to refer to them during the discussion, and at times you would see students adding to their notebook as well. These science talks seemed to serve as a wrap up to the day's lesson. Megan also utilized partners in two of the activities and in discussions. By asking two students to work or talk together, it helped ensure that everyone had a chance to talk and allowed students to try out their ideas before sharing them with a larger group. Overall, she stated that it was important for students to walk away with an understanding of the scientific content whether that understanding came from discussion or writing, but she believed that a great deal of it comes through the discussion, as she stated "discussion is what is going to refine their ideas" (Final Interview).

In addition to providing time for the students to talk about their ideas, Megan dedicated 28% of her science lesson time to writing in the science notebook. While she provided very little modeling on what a notebook entry should look like, she did address how the notebook should be used and what students might include in an entry. These included such things as, "Can you tape a piece of these materials into your notebook? Absolutely. Then, can you write about what you notice about it? Absolutely. The properties it had, what you know about this material" during the lesson on May 25. On May 26, she reminded the class of the following, "You can write as you go. Remember

to compare these to one another," and "As a scientist, you want to write down everything that you learn, big or small." In addition, she focused students on how to use it as a tool.

> My suggestion is that you open up your science notebook, you have it in front of you as a scientist, and you look at where you took notes about pinto beans; remember we were trying to learn as much as we could. So read through what you wrote about pinto beans and we're going to share some of those ideas. (Lesson, May 26)

While these statements are quite general in nature, they offer direction for the students while honoring Megan's belief that notebooks belong to the students and they should be the ones who make decisions of what and how to record.

Over time, Megan has come to believe that students should use the science notebook as a tool and she emphasized this in her classroom. In four of the lessons, Megan referred to the notebook as a tool and encouraged her students to use it as such. Examples of this include:

> We are going to use our notebook as a tool because that's what it is. We know that our notebook, we write in it, not just to write in it, we write in it so we can go back and look up information. (Lesson, May 26)

Also on May 26, she said to students, "Hopefully you're reading what you wrote, because that means, you know it's a resource." On May 27, she reminded students, "This would be an opportunity for you to go back into your notebook and be on the page for that question because remember our notebooks are a tool they are a resource. Read through what you wrote." Finally, on June 1, she asked students, "Where is your notebook? Because that is our tool, that's a resource; you should have the answer recorded in your notebook." This idea of the notebook as a tool was stated to students seven times throughout the lessons.

In order for the notebook to be a useful tool for the students, the focus needs to be on the content rather than what was done during science. Megan came to this realization over time. As she analyzed students' notebooks, she noticed that students focused on what they did that day in science, rather than the content they were learning. During this time, she came to realize that "there is a process to writing in the science notebook" that she had not really thought of before.

While she believes students are capable of recording the content, she realized that if she wanted them to focus on the content that she needed to provide modeling so they would know how to write in that manner, an idea that was discussed in the study group. She stated that modeling what a notebook entry should look like took a great deal of effort and time, but believed it was important because of the pay off in the end. Modeling was so important in fact, that she stated that it was not something to do only with the younger students, but that it should continue throughout their schooling, as notebook entries change.

She believes that supporting children to write in this way "is really important because it gets the children to think, … to rethink and analyze." While she stated that she has no proof, she believes that providing structure and pushing students to write about the "how" behind what they did versus just allowing them to write has made a difference in what her students put in their notebooks now compared to her first year of using them.

Megan pushed her students based on her strong belief that notebook entries should focus on content rather than what was done in science that day. To help with this, she would work one-on-one with students to address this issue as demonstrated in this excerpt from May 31:

Teacher	Did I ask what activity you did today?
Student	No
Teacher	Or your evidence on how you know what you learned? I learned, blah, blah, blah because … You just told me what you did today. You didn't tell me anything that you learned about solids. I just want you to answer that question. You answered something and that was fine, it was a good answer, but I want you to answer the question that was given to you.

The student's initial recording on the iPod was:

> Well, [my teacher] gave us these materials. She gave us lima beans, pinto beans, mung beans and cornmeal. She told us to sort the materials into the container it fits in. But, when we sort the materials, but the lima beans, she gave us these containers like you put the stuff in, it goes down, it goes like down. She gave us a small one, a medium, and a large, and then we, and then we when we're finished the lima beans we couldn't put them in the containers because the lima bean was too big and fat. So we got a scoop and then we scooped it up and put it in the container. That's how we did it.

Figure 3 is the students' final recording in his notebook: "I learned some solid's are small and big and some if the solid is big it coulb fit through the screan." [*sic*] While his final outcome may have lacked some detail, he moved away from what he did in science to what he learned in science.

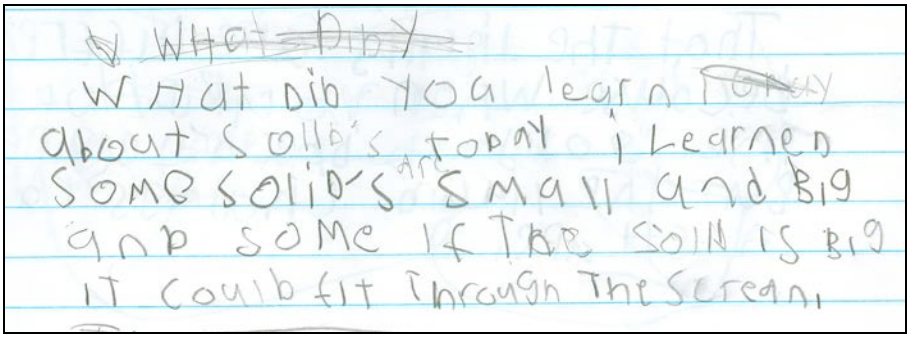

Figure 3. M16's notebook entry based on an iPod recording and discussion with the teacher.

Megan's practices shifted from implementing the science notebooks in a mechanical manner to supporting students in using the notebooks as learning tools. In order to make this shift, Megan put various structures in place to help her students make decisions about what and how to record their information. In addition, she ensured that students understood the importance of their decisions by making the purpose of the notebook explicitly clear to them.

Student outcomes.

Student outcomes are presented on three different levels. First, class results of a pre-posttest related to the solids and liquids unit under study will be shared. Second, results from a content analysis of notebook entries from all 18 students in the class are presented. Finally, three students' are examined in greater depth, looking more closely at their understandings based on a content and taxonomic analysis of their science notebooks over the year, interviews, and post-test results. Examples of student work are direct quotes, including spelling and grammar, from the original documents.

Class results of pre / posttests.

Megan's students demonstrated understanding of the content they were learning as verified by the pre- posttests. Table 1 shows the results of the pre- and posttests for the unit on solids and liquids.

Table 1

Percent of Students Scoring Within Point Ranges On Pre- and Post-tests – Megan's Class

Type of test	Point range	% of students	
		Pretest	Posttest
Performance (out of 12 points)	12-10	0	55.5
	9-7	35	22.5
	6-4	59	16.5
	3-0	6	5.5
Written (out of 9 points)	9-8	0	55.5
	7-6	6	17
	5-4	18	22
	3-2	46	0
	1-0	30	5.5

On the performance pretest, 35% of her students scored above 50%, while 78% scored above 50% on the posttest. When asked, on the pretest, to identify if a crayon was solid or liquid, the majority of students were unable to correctly identify the crayon as a solid and earned one point on this question. An example of an answer that fit this category was, "its' a likwit becase likwis' are more Better then a sodit." On the posttest though the majority of students were able to identify the crayon as a solid and provided an explanation that it had a defined shape, earning four points for the question. On the posttest, the student above wrote, "it is a solid becase it cant, chage its, own shape it stas, the shape." This sort of explanation was typical of most students in the class.

On the written pretest, only 6% of the students scored at least six out of nine points or 67%, while 72.5% of students scored in that category on the written posttest. When students were asked, on the pretest, to explain how solids and liquids were different, the majority of students scored zero points for the question, as they provided no answer, an incomplete answer, or an answer that did not make sense. Many of the students referred

to color to determine the difference between a solid and a liquid, such as this response, “a solid is different then a liquid because the solid is purple.” On the posttest though the majority of students scored all four points on this question, as they were able to identify that solids keep their shape while liquids take the shape of the container, such as this response, “I now that a solid has its own shape and liquids take the shape of the contaner”.

Science notebooks.

Out of Megan’s six lessons, 18 students created 57 notebook entries. All entries were analyzed using content analysis and results are presented as percentages in Table 2.

Table 2

Percentage of Science Notebook Entries Containing Various Elements – Megan’s Class

Notebook Elements	% of Entries
Basic Elements	
Date	72
Title	54
Focus Question	32
Drawings / Diagrams	5
Labels	11
Writing	100
Graphic Organizer	4
Content of Entries	
Addresses Science Content	68
Describes Science Activity	9
Describes Feelings	0
Contains a Claim	95
Contains Evidence	16
Contains an Explanation	39
Uses "because"	37

Ruiz-Primo et al. (2010) found that student achievement was positively impacted when students were engaged in the construction of conclusions, including the use of claims, evidence, and explanations. Within the lessons, it was evident that Megan

focused on conclusions; this same focus was apparent in the notebook entries. A claim, or an answer to the question being investigated, was evident in 95% of the entries. Sixteen percent of the entries provided some sort of evidence to support the claim and 39% supported the claim with some sort of explanation. An example (see Figure 4) of a conclusion, or all three parts, includes: “cornmeal is a solid and it is not a liquid Because liquids do not have there own shape and solids do and if I get cornmeal and put it in a cuntainer it will take the shape of the cuntainer but it will still have its own shape and if you get a liquid and put it in a container it will take the shape of the cuntainer so like liquids don’t have there own shape”. Within this entry this student utilized the word “because” in an attempt to connect a reason to his thinking.

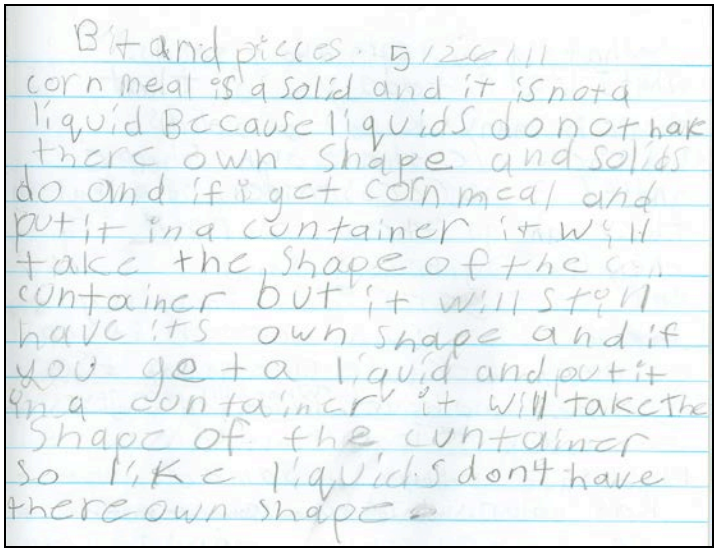

Figure 4. Example of a notebook entry that contains a full conclusion, student M12.

Deeper analysis of three students.

Three students were interviewed and their notebook entries over the course of the year were analyzed. The first 10 entries from each of their three science units were analyzed using content analysis and results are presented as percentages in Table 3.

Student M2 did not have 10 entries during the second science unit, so a total of 29 entries were analyzed for him.

Table 3

Percentage of Science Notebooks Containing Various Elements – Individual Students from Megan's Class

Notebook Elements	M1	M2	M3
Basic Elements			
Date	83	72	87
Title	50	48	63
Focus Question	13	21	23
Drawings / Diagrams	40	38	37
Labels	43	48	50
Something Glued in	33	28	43
Writing	70	76	70
Graphic Organizer	17	24	17
Content of Entries			
Addresses Science Content	43	79	70
Describes Science Activity	10	7	13
Describes Feelings	0	0	0
Contains a Claim	3	21	40
Contains Evidence	0	7	0
Contains an Explanation	3	17	33
Uses "because"	13	38	37
Entry Appears Incomplete	33	3	0

M1.

In the final interview, student M1 struggled to clearly explain the big idea of the unit, that solids have a definite shape while liquids take the shape of the container. She demonstrated some understanding of this concept with the statements such as, "if you put water on the table it can spread out." and "if you throw a … a rock at the floor it can not change its shape." However, these demonstrated a weak understanding, which was underscored by her response to the question of how she knows if something is a solid or a

liquid, she said, “if you move it and throw it, it cannot change its shape.” It was not surprising then that only 43% of her entries focused on the content being studied and that only 3% of her entries contained a claim or an explanation.

Five of the entries she made that contained content had drawings that supported this content in some way, such as a drawing of a beetle with parts labeled (Figure 5). An example of a written expression of content included, “when I push the plugn it moof the air the aire moof” (Figure 6). The claim and explanation she made came from one entry in which she was asked the focus question of “Is cornmeal a solid or a liquid?” to which she responded “cornmeal is a soled because it can have it on chap” (Figure 7).

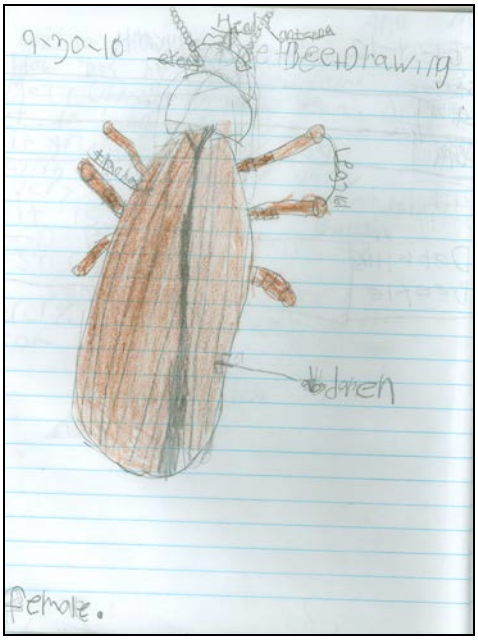

Figure 5. Example of a drawing that contains content, student M1.

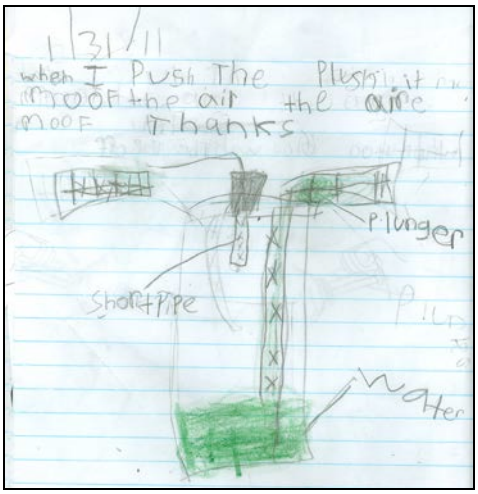

Figure 6. Example of written expression of content, student M1.

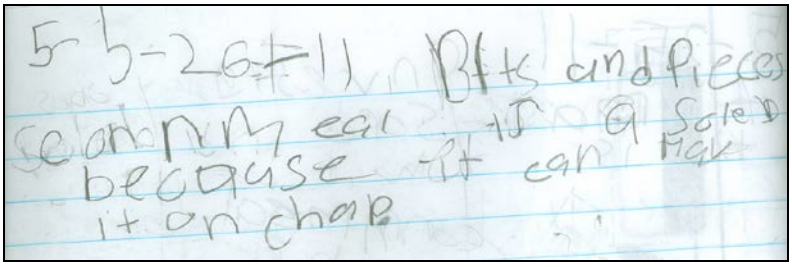

Figure 7. Example of an entry that contains a claim and explanation, student M1.

On her pre- posttest, she went from a score of four on her pretest to a score of eight on her posttest for the performance assessment. An example of how her responses changed on the performance test included: “object bcuse I no let it lok to me lat is liquid” on the pretest to “it is a solid because it can have it on hap.” on the posttest. On her written test, she went from a score of 0 on her pretest to a score of 4 on her posttest. In response to the question “How are solids and liquids different?” on the pretest she answered, “I now that the solids is in the wolr.” While on the posttest, her response was, “Wen you pot the solids it can Not Hach it can it can Havs it on shap. that can Hav its on chat But win you pot the liquids it can Not Have it on chap.” This response demonstrates that she has an understanding of the concept being taught and was able to put it in writing even though she struggled to verbalize it in the interview. This is an exception to the

pattern that students are typically better at expressing their ideas verbally than written; however, it should also be noted that M1 was very shy and was often a self-selected mute in class.

It should also be noted that 33% of her entries appeared as though they were incomplete, which may be due to a struggle with writing, as she stated that her teacher helped her learn to use the notebook by sounding out words for her to write. She seems to understand the basic elements of a notebook though as she included a date on most pages and stated the reason for doing such is to know when the entry was made. She also shared that entries should include such things as sentences, pictures, labels, a date, and a title so this information can be shared with others. While she believes her science notebook is important, she did state that her least favorite part about science is writing because then she has to share and she does not like sharing.

M2.

Student M2's entries contained content 79% of the time such as, "my mealworms hay 6 ligs." (Figure 8) and "I nodist that the win cand blo theeings because. I blu the fum ball." (Figure 9) He also demonstrated an understanding of the content of the solids and liquids unit, and in the final interview stated, "Solids and liquids are different because a liquid could change its shape and a solid cannot change its shape. A solid has its own shape."

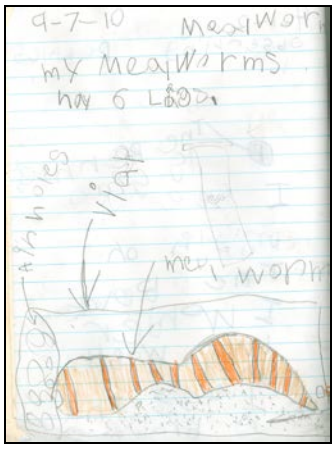

Figure 8. Example of an entry that contains content early in the year, student M2.

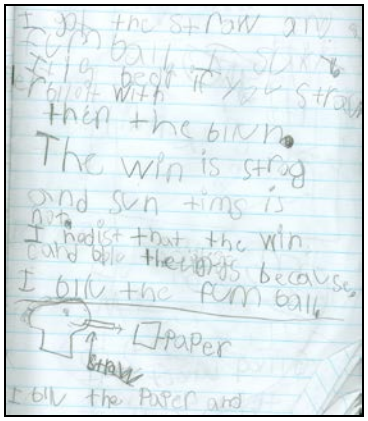

Figure 9. Example of an entry that contains content, midyear, student M2.

This level of understanding was also present on his pre- posttests. On his performance pretest, he scored seven points and wrote the following about a crayon, “it liquid because if you turn it its goning to tern in to liquid.” on this same posttest, he scored 11 points and stated that a crayon is “solid because it can’t chong it’s shap.” On his written test, he went from a score of three to a score of eight on the posttest. In answering “How are solids and liquids different?” he responded on the pretest with, “one is solid and one is liquid.” While on his posttest, he wrote, “a solid is different then a liqid because solid has it’s own shap and a liqid changs it’s shap.” Within his entries he included a claim 21% of the time, evidence 7% and an explanation 17%, as demonstrated by this example

(Figure 10), “Wen I push the plungr the air has no wer to go so the air pushis the wodr up in the uther barrel. this hpins because the air tacks the spas.”

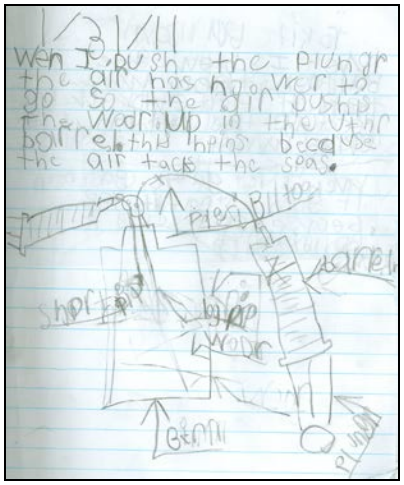

Figure 10. Example of an entry that contains a conclusion, student M2.

In the initial interview, student M2 demonstrated an understanding of what science notebooks should have in them and how they should be used. He stated that it is important to include a date and title on every entry so others will know what you wrote about and when you wrote it. He also stated that a notebook should contain evidence, which was why he wrote about the properties of materials, like cornmeal, or taped in the skin of a mealworm to show others that it had “shed” its skin. His explanation for why it was important to record information in his notebook sounded similar to Megan’s statements that the notebook is a tool. His reasons for recording included, “if you forget you might have to look in the science notebook” or so “you could remember what the stuff was that you have so if it’s like something poisonous.” Finally, he stated that his teacher helps him learn how to use the notebook by asking the students questions, which he answers and then writes in his notebook.

M3.

The notebook for M3 had content represented in 70% of her entries, such as: “the mealworms need food, water, air, and space to live.” (Figure 11) “The paper towel stad dry because when you hold it, [the vial, as represented in the picture], thiers air in side when you put it in the water thiers air.” (Figure 12) This example also demonstrates a strategy Megan decided to implement, the use of a picture prompt from the science curriculum materials, and then shared with the study group. In addition to content, she also included a claim in 40% of her entries and an explanation in 33%; however, she never included any evidence to support her thinking. As she worked with two syringes connected via a flexible tube to explore the idea that air can be compressed, she wrote, “When me and my partner push at the same time we can’t push because the air is being pushed into a smaller space and it makes it rely hard to push the plunger” (Figure 13).

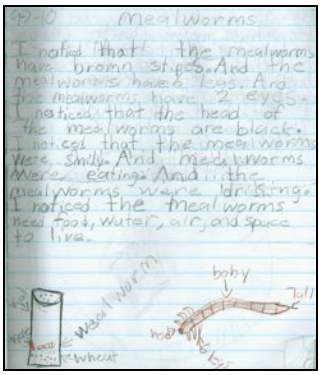

Figure 11. Example of an entry that contains content, early in the year, student M3.

Figure 12. Example of an entry that contains content, middle of the year, student M3

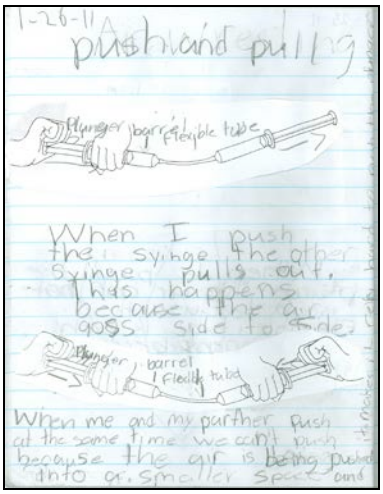

Figure 13. Example of an entry that contains a claim and evidence, student M3.

She had a strong understanding of the solids and liquids content as well, which was represented in her final interview, in her notebook entries, and on her posttest. When asked how she knew the difference between solids and liquids, she stated, “when you put a solid in a container it, it doesn’t change its shape and when you put a liquid in a container it does change, it, it makes, well looks the shape of the container. … I know because solids have their own shape and liquids don’t.” She wrote these same kind of thoughts in her notebook, such as “Liquid are diffrent because when I put the liquid in the contaner of a square it makes a square and when you put the solid in the contaner it has his own place.” (Figure 14)

Figure 14. M3’s understanding of the difference between solids and liquids.

On her pre- and posttests, she demonstrated this same understanding. On the performance pretest, when writing about a crayon, she stated, “It is a solid because it has dots.” On the posttest, she wrote the following about a crayon, “It’s a solid because it has it’s own shape.” Her overall score on the performance test went from an eight to a 12. On the written test, she went from a score of three to eight. She answered the question, “How are solids and liquids different?” on the pretest as, “Solid and liquid is different because the liquid is down and solid is like this” (drew an arrow to a picture of a solid that she had drawn). On the posttest, she answered that question as “A solid doesn’t change it’s shape. A liquid takes the shape of a container.”

Her thoughts on why a scientist should use a science notebook echo her teacher. In the final interview she stated that scientists use a notebook “like a tool… to help them” and went on to state that she can go back into her notebook to see what things are called and know about the properties of materials. She also said that the notebook is important because it contains information for her to tell the other kids. In addition to containing information, she also stated that a date and title should be included in every entry and that she used it to write about and label “stuff.” When asked how her teacher helps her learn how to use a science notebook, she stated that she helps her think about how to write and draw in the notebook and suggests she include samples in her entries.

Overall, Megan’s students demonstrated that they understood the content they were learning and the purpose of a science notebook. Their performance reflected Megan’s strong beliefs that the notebook should focus on content and serve as a learning tool. In addition, Megan scaffolded her students learning using a variety of strategies to focus student entries on the content and the elements of a conclusion. In response, her students

incorporated these elements within their entries and exhibited fairly well developed conceptual understandings on the posttests.

Summary of Megan.

Megan's beliefs and practices related to science notebooks changed over the course of time that she was at Jones ES and engaged in collaborative discussions as part of the science notebook study group. Although her initial science instruction was directive, she eventually adopted a more student-centered, hands-on approach, which was evident throughout this study. At this point in her career, she believes that students learn best by doing and that she is responsible for providing them with opportunities in which they can make sense of the experience, including the experience of using a science notebook. She strove to help students understand the importance of recording in a science notebook in order to help develop their scientific understandings. She went from providing her students insufficient guidance to structuring experiences to help her students focus on the content, and from seeing the notebook simply as a place to record what was done in science to seeing it as a tool that students used to support their learning.

The collaborative nature of the study group provided Megan with strategies she could use in her classroom. It also provided her with an opportunity to analyze her students' notebooks as well as the notebooks from others' classrooms; giving her a new perspective on what notebooks should look like. The study group also helped her develop a vision of science notebooks as tools to promote student learning, focused on the content and the development of conclusions rather than the activity. Finally, the study group gave her a sense of the importance of assessing science notebooks in order to move students' recordings forward.

Her clear purpose and explicit directions for the science notebook helped her students understand what and why they should record. While she struggled to find the time to implement notebooks in the manner she wanted, she felt it was time well spent, and it appears as though it was. Based on student interviews and work, it is evident that her students ended this unit with an understanding of the scientific content as well as an idea that science notebooks are tools to help them learn.

Elizabeth

Elizabeth, a white female, has taught for eight years, with the last three of those as a second grade teacher. Prior to coming to Jones, in her third year of teaching, she had not taught science or used science notebooks. Her own experiences with science in elementary school came from a basal and she stated in the mid-interview that she didn't really like science in high school, took only the minimum number of science credits required, and she only remembered taking an earth science course in college. She described how this made her feel when she knew she would have to teach science at Jones ES, "I think I was hesitant and a little scared to teach science just because I felt like I didn't know enough about it. I didn't know enough background about what I was teaching."

Initial beliefs and practices.

In this section I share what Elizabeth remembered about her beliefs and practices when she first came to Jones ES and before she participated in the study group. Elizabeth did not like science as a student and avoided teaching it prior to coming to Jones ES. When she did begin teaching it, she stated that she thought it was something that "you did for an hour and you were done and that was it" (Initial Interview). She focused on doing

the activity. Her own elementary experience with science had been reading based, so doing the activity was most likely a big step for her to take. She stated, that "you learn from doing, so as I'm doing it, I am learning with the kids."

Like Megan, science notebooks were new to Elizabeth when she first arrived at Jones ES. In the initial interview she stated:

> I remember when the school first opened you know we had talked about science notebooks a lot but I had never done them. You know, in the beginning I don't know if anybody really had success with using them or we even knew what to do with them.

Elizabeth stated that in the beginning, she read books and talked with other teachers in order to better understand how to implement science notebooks in her classroom. "I just thought of it as, okay take out your… I thought of it as a journal, and you know they would take what they did and write down maybe what they thought, I mean it was very informal." Since she was not comfortable with using the notebooks, she said she would have students write in them but they never went back to that information. They would record that day and put the notebook away.

Like Megan, Elizabeth was drawing from her prior experiences, which were limited, and the resources she had been given in order to learn how to teach science and to integrate the use of science notebooks within the hands-on science she was expected to teach. While she was not really comfortable with science, she was willing to teach it and approached it with the sense that she would learn these ideas right along with her students. This was the same approach she used with science notebooks, although she utilized them in a manner that equated to a "bound workbook" in which students recorded what they did but did not use them for real learning purposes.

Influence of the study group.

In 2009, Elizabeth joined the science notebook study group, in order to learn how to use notebooks in a way that would benefit her students. She had heard others talk about the successes they were having using science and this prompted her to join, as she explained:

> I think from hearing the success that other people have had, because … once you hear that people are successful at it and they're seeing growth in their kids then I think that I want to do it more and I want to try it with my kids. (Initial Interview)

She became an active participant of the study group, taking ideas back to her classroom, implementing them, and sharing results at the next meeting. She participated in all four of the videotaped meetings. In these meetings, she shared ideas she had implemented such as providing each table with a set of vocabulary cards and having students look back through their notebooks to highlight important details to use in answering a focus question. At the March meeting, she discussed how she believed students find a blank page to be daunting and the thought that she does not provide enough time for her students to talk

> I know I'm guilty of not having them talk to each other enough before they start writing. And I think it's just like a time constraint. I think I give them enough time to write, but I don't think they have enough time to talk to each other about what they have just done, what they've noticed. So …

She decided to build more time in for talk as a result of this conversation.

Similar to Megan, she also pushed ideas. She started the conversation on content (displayed in Megan's case) as she realized that she was seeing a lot of students using "I notice…" in their notebook entries but not providing any sort of evidence to back up their thinking. She went on to discuss how important she feels it is to explicitly teach students

to include evidence to get to the content and how "because" can help students with this, as evidenced in this dialogue about Fulwiler's (2007) book in January:

Annie	I really liked the frames... The very simple one, "I predict _____ because _____." Because a lot of kids will say, you know, I think this is going to happen and they don't finish it up with because, they just, I think this is going to happen and they don't tell you the because, and so this simple frame. But, I like how it goes into the more different ones, you know the ones later on where it shows the, "I noticed…" "My evidence is…"
Teacher 7	It was a pretty convincing argument that the author gave about the sophistication of "because" in the thinking. You know something that you might think is not that big of a deal, but they were like, "Wow," I kept thinking, "Wow, that's bigger than I actually thought it was." You know for a kid to say because and justify their thinking seems like something small.
Teacher 2	(inaudible) I do, the reasoning behind it.
Elizabeth	I really tried to stress that this week because we started new and I told them that they couldn't just say that the answer was yes or no because, and I think it even mentioned it in here, if other scientists were to read their notebook then they wouldn't understand why something happened, so I really tried to stress the word "because" after each thing. Not necessarily a prediction, but what we learned. So they have to prove their thinking with that word. I liked that part too. I mean it's such an obvious word, but…

During the meetings, it was evident that Elizabeth was taking ideas from the group and implementing them within her classroom, as she shared outcomes with others. One example of this was the use of the vocabulary cards at each table. She explained that one time she forgot to give students a new word and she had students asking for it that day as they recorded in their notebook. In the three interviews, she discussed how she incorporated many ideas from the study group into her teaching. One of these ideas was to provide students with a checklist they could use to self-assess their drawings to see if they included everything they should.

Another was modeling writing, although she stated she used this more in the beginning of the year, as she felt students no longer needed so much modeling later in the year. She also talked about how she used the class notebook to record information in and to model how to use it as a tool, in hopes that "they're going to be able to go back in their notebook and use it again." In addition, she provided students with sentence starters to use as they wrote individually or within a small group. When doing this she emphasized the importance of students providing the "why" behind their answer.

In the interviews, Elizabeth also talked about how the study group had caused her to think about her practice and what she thinks is best for the students in terms of science notebooks. While she believes the study group has given her a direction in which to lead her students to help them understand what to write down in order to get them to the big ideas of science, she struggles with how much support to provide them. Specifically, in the initial interview, she brought up sentence frames, and that while some in the study group think they offer the support students need, Elizabeth questioned if they may go too far, as she thinks students are capable of producing the same types of results on their own. During the February study group, there was some discussion about assessing the notebooks, which Elizabeth questions and brought up in the initial and mid-interviews. She stated that while she feels it is important for the teacher to know what students are doing in the notebook, she does not feel right about picking them up and making comments in them, as was suggested, but then questioned if this might help students. In the mid-interview, she said, "Maybe I don't disagree with it, but I want to know more about it, I want to learn more." That was Elizabeth's approach to the study group, she

was there to learn, was open to new ideas, and incorporated new ideas into her beliefs and practices.

The study group seemed to help Elizabeth push her thinking of the notebook beyond that of a journal to that of a learning tool. Her reflective nature caused her to question concepts she was learning about within the study group, which pushed her to develop new beliefs and practices.

Struggles.

While Elizabeth finds support amongst her colleagues, she has encountered challenges and struggles in the implementation of science notebooks. Like Megan, one of Elizabeth's biggest struggles is the fact that 74% of her students are second language learners and she feels as though writing itself is a struggle for them and that they can explain their understandings better verbally than they can in writing. This struggle has led her to provide various supports, but then she questions how much support she should provide.

> I give them support but sometimes I struggle with giving them too much support, because I mean … your science notebook doesn't have to be perfect and I mean as long as you can read it and someone else can make sense of what you're telling them then I mean it's not a final copy or anything so… I struggle with giving them too much support. We've talked about using sentence strips for some kids… and I don't know, I think it helps but at the same time I don't know, I mean I know they can do it they're just so worried about not getting it down correctly that they freeze. (Initial Interview)

Her fear is that if she provides too much support that the notebook focus becomes what she wants as the teacher rather than what the child believes is important to have in there. However, she also recognizes that if the students cannot read what they have written then the notebook does not serve the purpose of helping them learn.

Another struggle Elizabeth has encountered also deals with this idea of notebook ownership and assessment. This struggle stemmed from a discussion that took place in the Feburary study group about assessing the science notebook and providing feedback to the students.

> I've never given them feedback in their science notebooks. Partly because I didn't know if I was supposed to or… I just, I don't know … because it is their own personal tool so I don't know I always thought it was just kind of their notebook, their ideas. (Initial Interview)

In this area, she questioned if students would use the feedback or if she would need to teach them how to use such feedback in order to improve their notebook entries. Overall, she felt as though she was able to get a sense of what students were able to do and not do and provide direction by looking over their shoulders as they recorded, an idea with which Megan would disagree.

Finally, Elizabeth struggled, like Megan, to find opportunities for her students to write within this unit. She felt as though the first two sections, "solids" and "liquids" were much more observational in nature and did not provide a lot of opportunity for good scientific writing, but the activities that came later "made it easier for them to write."

Elizabeth's struggles demonstrate that she is reflective and that the study group is creating some disequilibrium for her related to her beliefs and practices related to science notebooks. She is no longer concerned with what to do, but is now concerned about how to best help her students learn as much as possible using the science notebook.

Current beliefs and practices.

While Elizabeth entered teaching with an aversion to teaching science and no knowledge of science notebooks, she learned to embrace both and incorporate science throughout her day. She now enjoys teaching science and believes it is just as important

for her students to learn science as it is for them to learn math or reading. She believes, like Megan, that her students learn science by touching and interacting with the materials and that it is important for them to be able to talk with one another about what they have learned. Elizabeth now believes that science "encompasses all the other subjects" and finds that she pulls science into her reading, writing, and math lessons or pulls those subjects into science, making it more than the explorations she used to view as "science time."

She now values science and the use of a science notebook and believes it helps students learn in all areas while they are having fun. She believes the value she now places on science and science notebooks is reflected in the value her students place on both as well. She believes students learn in a social setting, and she discussed how she structured lessons following the gradual release of responsibility (Fisher & Frey, 2008), which Elizabeth summarized as "I [the teacher] do, you do together, and then you do alone." This sort of structure builds on the social community aspect of working through something together before expecting students to work through it on their own.

Beliefs about science notebooks.

Elizabeth's beliefs about science notebooks have changed over her years of using them at Jones ES. In the initial interview she stated that she used to view science notebook use in a very informal manner, almost like a journal, in which students wrote about what they did in science and maybe what they thought; however, now she sees notebooks as having much more purpose and rather than focusing on observation she states, "it's more about the content, … there's a real reason why we are writing in it and

[students] see that they can use what they've written later on." She now sees the science notebook as a purposeful part of science, as she described in the initial interview:

> Well now the notebooks are, I mean, we pull out our notebooks now all the time because I think…, that, I mean it just shows that you're having a purpose it's not just to write down your thoughts and your feelings, it's… you know it's a place to write down what you've learned. So I don't know the notebook is more… I think it has more purpose in learning than a journal does."

Like Megan, Elizabeth refers to the notebook as a tool in her interviews; however, she does not yet see it as a tool for her instruction. She refers to the notebook as both a personal tool and a learning tool for students. As a personal tool, she believes it is similar to a journal and that it is the student's notebook with their ideas. However, she also refers to it as a learning tool that "has more purpose in learning than a journal does" and that students should go back into it to review information in order to help them in the future.

Based on the survey, she believes that notebooks should contain drawings, labels, data, and writing and that they should be used to record observations and procedures, to make sense of the data, and to think critically. In an interview, Elizabeth stated that she views the notebook in two ways, as a place for recording information and collecting thoughts and as a written product based on those thoughts and that information. In addition to the content students record, Elizabeth also believes that it is important that the written product within the notebook reflect conventions of good writing, such as capital letters, punctuation, and spelling "so people can actually read your writing, because if you write stuff and no one can read it, then it's basically … a waste of time because nobody else can learn from you" (Final Interview). This last part sets Elizabeth's goals apart from Megan's, as it pulls the focus away from the science content.

In the interviews, Elizabeth discussed how she helps students learn to use notebooks in this manner. Elizabeth believes that students need assistance and that it is important to model both before and after students make their own notebook entries. While Megan thought modeling was important too, she tried to limit it to encourage her students to take ownership of the notebook; modeling before an entry might discourage this individuality. Elizabeth also believes that she is able to guide her students' writing through the use of "good leading questions" that help them come to the big idea. Beyond writing, she believes it is important to model explicitly how to use the notebook in specific ways, such as finding important information or using feedback. To do this, Elizabeth stated that she utilizes the gradual release of responsibility model (Fisher & Frey, 2008) of I do, we do, you do.

In interviews, Elizabeth stated that her goal for the science notebook was for students to be able to convey what they were thinking in writing. As part of that thinking, she wanted students to be "able to explain why they answered the question that way" and emphasized the use of "because" to help students provide this explanation. This emphasis on writing was evident in her lessons as well, as demonstrated by the following statement from the lesson on May 11:

> All right, so, I've given you a chance to talk about it, now it is your time to write about it. Since we have already talked during this time, during our writing time there should be no talking, because you have already had the chance, I gave you the chance to talk with your neighbors about it. So, to answer the question is going to be a no talking writing time.

She also reiterated the importance of using "because" to her students as this exchange from the lesson on May 9 demonstrates.

Teacher	Remember if you are explaining something what is that word that we should put in there?

Students	Because
Teacher	Because. So, look over your sentences and see if, “Hmm, maybe I need to explain this more and put why they helped me,” because will help explain that.

Overall, Elizabeth now believes that the purpose of the notebook is for learning and not just recording thoughts and feelings related to science. She feels that the use of claims and evidence are important to help students with this learning and to get to the big scientific ideas. The focus on claims and evidence has given her a direction and helped her teach her students what kinds of information should be in a science notebook.

While her beliefs have shifted from viewing the science notebook as a journal to that of a learning tool, she still focuses on some mechanical aspects, such as spelling and grammar, along with the science content. She recognizes the importance of her role in helping her students utilize the science notebook, focusing them on what and how to record, but did not talk about helping them learn to use it as a tool. Although she has altered her original beliefs, she is not as far along as Megan in her understanding of the notebook as a tool.

Practice.

Elizabeth believes that science notebooks are important tools that help students learn the science content they are studying. It is important to understand her knowledge of the content, since it can impact her instruction and student learning. Elizabeth stated in the mid-interview that she wanted her students to understand “that liquids take the shape of whatever you put them in” and that they can be poured. In addition she wanted her students to be able to identify the different properties of solids and liquids. Elizabeth did not state her goals for the content as clearly as Megan, who wanted her students to be

able to define the differences between a solid and liquid using evidence. Elizabeth's focus on the content played out in classroom discussions, as demonstrated by the following dialogue from May 9:

Student 1	If something is a solid and I put it in a container it's still a solid unless I do something to it.
Teacher	So, it's still a solid, so will it change or will it stay the same?
Student 1	It will stay the same
Teacher	It will stay the same. If we put a solid in the container it will still stay the same. What do you know about a liquid?
Student 2	When you pour it inside something it will take the shape of the container and …
Teacher	Help him out _____.
Student 3	And turn into the shape.
Teacher	It turns into the shape.

While Elizabeth talked about the new purpose she had for science notebooks, the notebook was not evident in every lesson; however, Elizabeth incorporated writing of some form in all three of the lessons. In the first lesson, on May 9, science notebooks were not mentioned at all; however, after some exploration time, students completed a small group writing activity in which they claimed whether a material, such as rice or lima beans, was a solid or liquid and supported their claim with evidence from their exploration. In the other two lessons, students had their notebooks out during the exploration time. They had designated writing time after completing the exploration in one of the lessons, and they added to their notebooks, while Elizabeth made an entry in the class notebook, in the other lesson. When she did incorporate notebooks and writing

in science, she was purposeful and provided structured experiences. She explained in the initial interview how having a purpose for the science notebook helped her guide her students' use:

> Now I know the direction I want to lead my kids into to get them to that big idea and what they need to write down; their claims and the evidence that they see from what they're claiming. So just knowing what needs to be in a science notebook entry to get you to the big idea has helped me… teach my kids what needs to be in there.

Elizabeth supported her students' use of the science notebook by providing a variety of scaffolds, including: a class notebook, graphic organizers, sentence starters/frames, focus questions, vocabulary cards, discussion, group writing, and notebook sharing. She utilized a class notebook on the SmartBoard, in which she would model elements of a notebook as well as organizational strategies, such as the graphic organizer of a box and T-chart for comparing similarities and differences, something discussed in the study group. She set this graphic organizer up in the beginning of the lesson and then students created this same graphic organizer within their own notebooks and used it to record similarities and differences between solids and liquids in bottles. At the end of the exploration time, Elizabeth used the class notebook to compile students' thoughts on the similarities and differences of solids and liquids in bottles, and encouraged students to add to their own notebooks as she recorded information on the SmartBoard.

In addition to modeling, Elizabeth also provided her students with a simple sentence frame of "We think the _____ is a …" to help them write about whether the material was a solid or liquid. Another way in which Elizabeth helped her students focus their writing was through the use of focus questions, such as "Are these materials a liquid or a solid?" and "How did you use the screens to help you separate the soup mix?" Since

Elizabeth believed that students were bogged down in the writing process because they didn't know how to spell something, she provided each table with a set of vocabulary cards, which contained the vocabulary related to the lesson. Students kept these cards in an envelope at their table and would use them as they wrote in their notebooks. Use of these cards was evident in the videos, as students would pull a card towards them as they were writing and then put it back in the center of the table where other students could reach it.

It was evident that Elizabeth viewed learning as a social endeavor, as she incorporated supports that encouraged students to learn from others, including discussion, group writing, and sharing. In all of the lessons, Elizabeth led students in a discussion of the scientific ideas. These discussions were usually sandwiched between the exploration and writing times, as in this example from the lesson on May 11:

> All right so before we write about this I want you to have a chance to talk about it with someone at your table, so … the one who is sitting across from you is the person you're going to be talking to. So, I am going to give you about two minutes to discuss how the screens helped you when separating the soup mix. So, go ahead and start to talk with the person who's sitting across from you.

These discussions were very different from Megan's "science talk" which encouraged student facilitation of the discussion.

In order to help students articulate their thinking, in one lesson, Elizabeth had students work in small groups to write a response to the question "Are these materials a liquid or a solid?" She provided them with a sentence starter, as stated earlier, and students worked in groups to create a "poster" containing a claim about whether the materials were a solid or a liquid and evidence to support their thinking. All groups correctly identified the materials as solids and provided some sort of evidence, as the

following example shows. “We think the mung bean is a soind because it is hard and if you put a srew in a cup full of mung bean it would not sink because it is a soind.” (Figure 15)

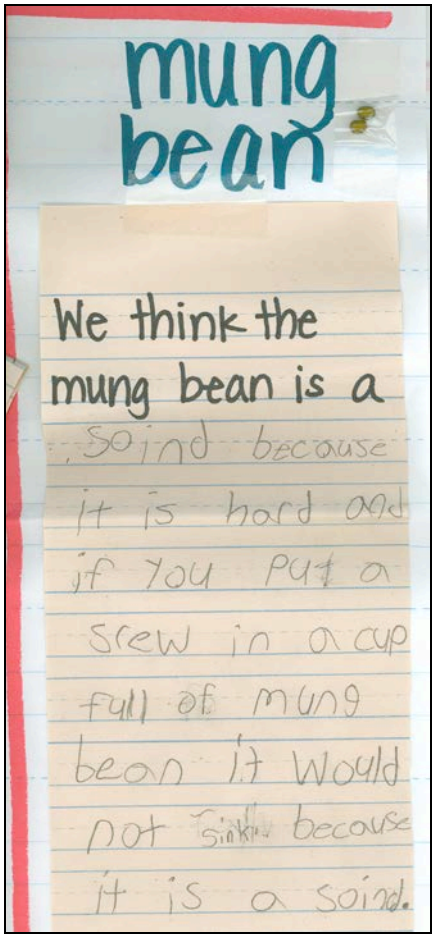

Figure 15. Example of poster produced as part of small group writing activity.

Finally, in two of the lessons, Elizabeth provided time at the end of the lesson to have students share what they had written. Students would pass the microphone and read from their group paper or their personal notebook. This was very different from Megan’s sharing at the end, where students used their notebooks as a reference to discuss the concept they had worked on that day rather than simply reading their entry. In the third lesson, students shared their observations with the class as Elizabeth recorded them on the SmartBoard and encouraged students to add information to their own notebooks, with

statements such as, “if you don’t have these things written down, cause I noticed a lot of you didn’t have things for the same, you should be writing these down with us.”

Over the three lessons observed, Elizabeth dedicated 16% of the time to writing about the science concept, whether in the notebook or creating a group “poster.” She emphasized use of the notebook on May 12 with statements such as, “as you are exploring you’re going to need to be recording in your notebook” and “so if you don’t have anything written down you should probably get that written down into your notebook because we’re going to be talking about this more in the next couple of days so get those down.” Beyond emphasizing the need to record information in the notebook, Elizabeth also emphasized the need for students to include basic elements of a notebook such as the title and focus question with statements such as, “here is our title, ‘Solids in Bottles,’ so, go ahead and write the title at the top of the page” during the lesson on May 12, and on May 11 she stated, “I want you to write down the question. I want you to write [it] down in your science notebook.”

While Elizabeth believes that the notebook is a tool and that students should use it as such, she did not refer to it as a tool in any of the lessons examined for this study. Her direction to students about having information in the notebook in order to talk about it was the closest she came to referring to the notebook as a tool. In the final lesson, she also referenced using a graphic organizer in the past and asked students to recall what that graphic organizer was, but she did not direct them to look in their science notebooks. This is in contrast to the seven times that Megan referred to the notebook as a tool throughout her lessons.

Elizabeth moved beyond using the science notebook as a “bound workbook” and focused on using it to develop scientific understandings. She provided a great deal of scaffolding, focusing her students on what to record rather than helping them develop an understanding of how and why to record.

Student outcomes.

Student outcomes are presented on three different levels. First, class results of a pre-posttest related to the solids and liquids unit under study will be shared. Second, results from a content analysis of notebook entries from 18 out of her 19 students in the class are presented. Finally, three students’ are examined in greater depth, looking more closely at their understandings based on interviews, post-test results, and a content and taxonomic analysis of their science notebooks over the year. Examples of all student work are direct quotes, including spelling and grammar, from the original documents.

Class results of pre / posttests.

Elizabeth’s students demonstrated a great deal of growth in their understandings of solids and liquids as demonstrated on the pre- posttests. Table 4 shows the results of the pre- and posttests for the unit on solids and liquids for her students.

Table 4

Percent of Students Scoring Within Point Ranges On Pre- and Post-tests – Elizabeth's Class

Type of test	Point range	% of students	
		Pretest	Posttest
Performance (out of 12 points)	12-10	0	6
	9-7	6	72
	6-4	94	22
	3-0	0	0
Written (out of 9 points)	9-8	0	17
	7-6	11	49
	5-4	50	28
	3-2	33	0
	1-0	6	6

Only 6% of her students scored above 50% on the performance pretest, while 78% scored above 50% on the performance posttest. When asked to identify whether a crayon was a solid or a liquid, an example of a typical answer on the pretest was "it's solid because it's a wite croayn.", which gave the student a score of two points on that question, as he was able to identify it as a solid, but his only evidence to support his thinking was to name the object. On the posttest, however, students typically provided properties of the material to support their answer, such as "the crayola is a solid because it hard and it opeqe.", which gave the student a score of three points for this question. A top scoring answer, four points, needed to include the idea that a solid maintains its own shape, as seen in this example, "a carayon is a solid Because it doesen't make the shape of the bottle and you can separate it from anything. and it makes noies."

While not as many students did as well on the written test as the performance test, 66% of Elizabeth's students scored at least six out of nine points on the written posttest compared to 11% on the pretest. When asked to identify how solids and liquids were

different on the pretest, most students provided an inaccurate explanation or gave an accurate example of a solid or a liquid but not both, such as “Becuse solid is gas and Liquid is water.” This type of answer resulted in one point for this question. On the posttest, this same student scored four points with the answer, “Solids and liquids are Difrint Because. Liqwids take the hole space. and solids Dont”, because she was able to correctly identify the big idea that solids have their own shape while liquids take the shape of the container. However, most students still struggled with this question on the posttest and referred to the properties of solids and liquids, such as “they are different because a solid is hard and a liquid is bubbly” resulting in a score of three points for that question.

Science notebooks.

Out of Elizabeth’s three lessons, students created a group writing within one lesson and notebooks were utilized in two of the lessons. Within those two lessons, 18 of her students created 37 notebook entries. The 37 notebook entries were analyzed using content analysis and results are presented as percentages in Table 5.

Table 5

Percentage of Science Notebook Entries Containing Various Elements – Elizabeth's Class

Notebook Elements	% of Entries
Basic Elements	
Date	95
Title	100
Focus Question	49
Drawings / Diagrams	0
Labels	0
Writing	100
Graphic Organizer	51
Content of Entries	
Addresses Science Content	86
Describes Science Activity	14
Describes Feelings	5
Contains a Claim	30
Contains Evidence	5
Contains an Explanation	22
Uses "because"	43

While 86% of the entries focused on scientific content, only 30% of them contained some element of a conclusion, which has been shown to lead to higher student achievement (Ruiz-Primo et al., 2010). This may be due to the fact that students were asked to respond to a question in their notebooks in only one of the three lessons examined for this study. This question was posed in such a way that students could make a concluding statement, which would include a claim, evidence, and explanation. Of the elements of a conclusion, the most prevalent was a claim, which was represented 30% of the time. These claims were supported by evidence 5% of the time and by an explanation 22% of the time. An example of an entry that contained both a claim and an explanation includes, "the litolest scro help me separat the corn meal the medam ua hepd me seperat the gren bens baecase the scars wer medam and the grens bens wer litol" (Figure 16).

Elizabeth emphasized using the word “because” to help students explain their thinking further, and it was evident in this entry as well as 43% of all of the entries analyzed.

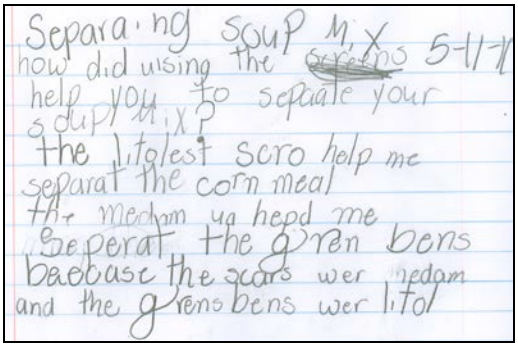

Figure 16. Example of an entry that contained a claim and explanation, student E5.

Deeper analysis of three students.

Three students were interviewed and notebook entries over the course of the year were analyzed. The first 10 entries from each of the three science units were analyzed using content analysis and results are presented as percentages in Table 6.

Table 6

Percentage of Science Notebooks Containing Various Elements – Individual Students from Elizabeth's Class

Notebook Elements	E1	E2	E3
Basic Elements			
Date	57	63	47
Title	50	43	47
Focus Question	17	20	13
Drawings / Diagrams	33	37	40
Labels	13	17	17
Something Glued in	30	33	27
Writing	70	73	67
Graphic Organizer	13	17	13
Content of Entries			
Addresses Science Content	67	63	67
Describes Science Activity	37	13	23
Describes Feelings	7	0	7
Contains a Claim	30	40	27
Contains Evidence	10	7	1
Contains an Explanation	13	23	20
Uses "because"	23	23	17
Entry Appears Incomplete	10	17	13

E1.

Student E1 struggled to clearly articulate her understanding of solids and liquids during the final interview. She started by stating that liquids take the shape of the bottle, and that solids, like rice, take the shape of the bottle as well. When pressed further, she explained that solids are "something that you use or put on" and that liquids are "something like water, juice." At this point, while she has some understanding of the big idea that liquids do not have a defined shape but take the shape of the container in which they are stored, she reverts to defining solids and liquids through examples. This same confusion was represented in her written posttest, in which she answered the question of

“How are solids and liquids different?” with “smoe are for Eat and some are for dreek.” On the performance posttest, she was able to correctly identify the objects as solids or liquids, but defined the items by their properties; such as saying the lotion was a “liquid Becase it move slow.” On the performance pretest, she had a score of four out of 12, as she could correctly identify only one of the materials as a solid or liquid. On the performance posttest, she was able to correctly identify all of the materials as solids or liquids, but could only define them by their properties as demonstrated previously, thus earning her a score of eight out of 12. On the written test, she scored a five on both the pre and posttests, as she struggled to identify differences between solids and liquids on both tests.

Over the course of the year, 67% of her 30 entries focused on the content being studied, 30% contained some sort of claim, 10% contained evidence that supported her claim, and 13% contained some sort of explanation that aligned with the claim. A main focus in this classroom was on the use of the word “because,” which was found in 23% of her entries. In three of her entries that addressed the content being studied, she utilized pictures to convey this understanding, such as the drawing of a waxworm with body parts labeled (Figure 17). Most of her understandings of the content were expressed in writing, as this example shows, “”I put in the vial a pes of papr and they put the vial in the wrer and sutis it ges wet and sutis it duset get wet. Bcus the papr ges stuk in the air.” (Figure 18) This example also demonstrates her use of a claim and an explanation that includes the word “because.” Another example of a claim and an explanation comes from her entry about a tower made out of solid objects. She wrote, “The propertier that made my

tower stand up are things that were rigid, hard, flat. Because if it wasn't it would fall down." (Figure 19).

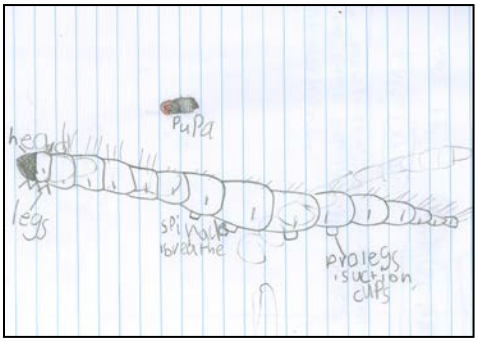

Figure 17. Example of an entry that conveys understanding through a drawing, student E1.

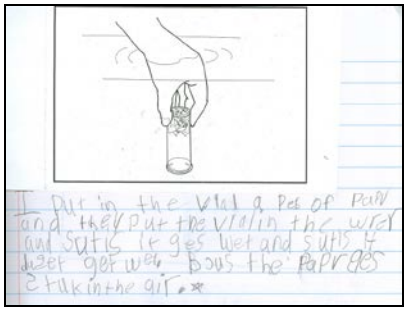

Figure 18. Example of an entry that conveys understanding through writing, student E1.

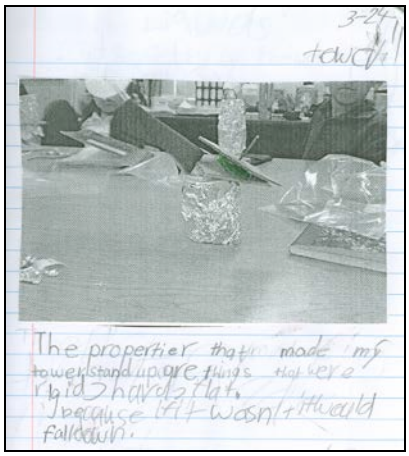

Figure 19. Example of a claim and explanation within an entry, student E1.

When asked in the initial interview about why science notebooks are important, she stated that writing in them helps her know what she did and that she can share it with the teacher. She also felt that scientists use notebooks to write down the things they

investigate, but when pushed further on this, referred to how she uses the notebook to glue papers into it. When asked about the specific elements of a notebook, she was able to state that a date and title are important to include in order to know when and what she was investigating, but did not include these as important things to put in every notebook entry, which is supported by the fact that only 57% of her entries contained a date and only 50% contained a title. While she believes that her science notebook is important for writing what she did, it appears as though she may not have a strong understanding of the purpose, as she felt one of the most important parts of the science notebook was "when it's science pocket day, we get to copy and then put it in your pocket for teachers to read it, then give you a little present" (Initial Interview).

E2.

Student E2 struggled to convey a conceptual understanding of the difference between a solid and a liquid. In the final interview, he explained that the difference could be determined by touching the material and that if "it is hard, then it is a solid. Then if it is a liquid … you can't touch it, it goes in." He also described the difference between them as "some solids are hard … some turn to a liquid and … some solids don't turn to a liquid." While this shows that he understands that materials can undergo change, he was not able to clearly identify the idea that a solid usually maintains its own shape while a liquid takes the shape of the container. These same ideas were conveyed on his pre and posttests. On the performance pretest, he scored five points total and used the phrase, "liquid because it is white," to describe both the crayon and the lotion. On the performance posttest, he scored six points total and stated that the crayon "is a solid and a liquid because is melts." and stated the lotion "is a liquid because it viscous." While this

demonstrates his understanding that materials can change and that he can use properties to describe an object, it again lacked the essential understanding. This was also seen on his written tests. On the written pretest, he scored two points total. He drew a picture of what might have been a saltshaker for a solid and an octopus for a liquid and answered the question of "How are solids and liquids different?" with "the solid is little and liquid is big". On this same question on the posttest, he responded "the solid is hard and the liquid soft." and drew and labeled a rock for a solid and drew and labeled a glass of "werdr" earning a score of six points total. His notebook entries also focused on the properties of the solids and liquids he explored and did not demonstrate a deeper understanding of the bigger idea being studied.

Over the thirty entries examined, 63% of his entries did contain content related to the material being studied. Some of this content was represented in drawings, such as that of a labeled waxworm (Figure 20) while some were represented in writing, such as "in the balloon thers air trap in the balloon. The balloon was log and bid Bekus in the balloon wus air" (Figure 21). This example also demonstrates how Elizabeth incorporated a strategy, providing students with a visual prompt from the curriculum materials, from the study group into her practice. Forty percent of his entries had some sort of claim that was aligned to the content, 7% contained some sort of evidence aligned to that claim, and 23% contained an explanation that supported the claim, as was demonstrated in his entry about the balloon. Within this entry, it is also evident that he has picked up on the teacher's emphasis of the word "because," although not spelled correctly. This use of "because" was evident in 23% of his entries.

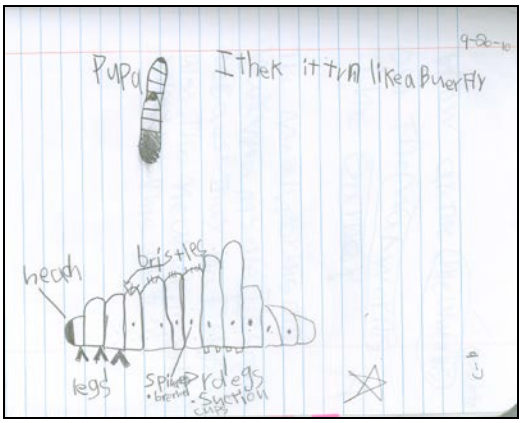

Figure 20. Example of content represented through a drawing, student E2.

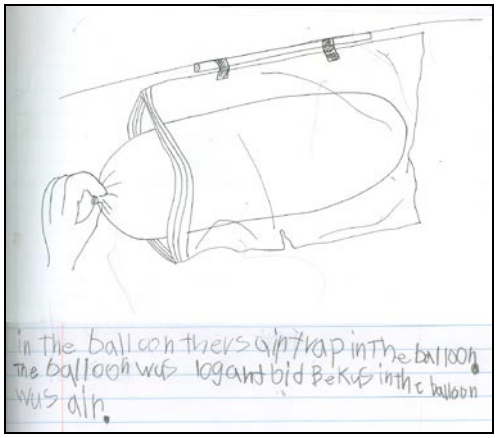

Figure 21. Example of understanding of content demonstrated through writing, student E2.

In the final interview, E2 stated that the teacher helped him know what to put in the science notebook, like labels, so others will know what something is. While he talked about drawing in his science notebook, he mentioned several times that it is important to include writing so others could read and understand what you are saying and know what the picture is about. When asked about including a date on the page, he stated that a date helps others “know when you did it” and the title helps him know “what is the title.” When asked how he uses his science notebook, he stated that after he writes in it, he reads from it “so they can understand.” His thoughts on the notebook align with Elizabeth’s ideas that the notebook should focus more on the understanding than what was done.

E3.

Student E3 was not in attendance for the last two weeks of school, and therefore did not take a posttest nor did she participate in the final interview, making it difficult to interpret her understandings of the concept. Her initial understandings of solids and liquids were defined by the properties of the materials. She described the crayon as "a solid because it is hard" and the differences between solids and liquids as "solids are hard and liquids are watery." Her initial scores on the pretest reflected these understandings with a total score of nine on the performance test and a total score of six on the written test. In two of her notebook entries, near the end of the unit, she talked about the bigger idea of solids and liquids. In answering the question, "Is toothpaste a solid or a liquid?" she wrote, "I think that the tooth paste is a solid becauses it does not take the shape of the contaner." On the next page she wrote, "I still think that it is a solid because it dis allved because liquids don't do that." (Figure 22) These entries demonstrate that she has an understanding of the bigger ideas of solids and liquids and the differences between them.

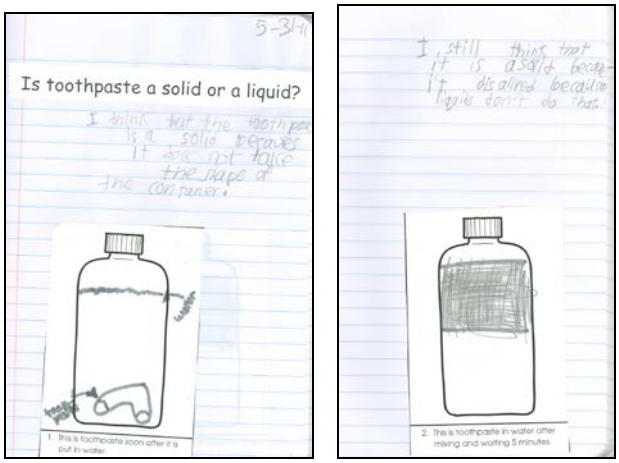

Figure 22. Student E3's understanding of the difference between solids and liquids.

Within her 30 notebook entries, 67% contained some reference to the content being studied. Twenty-seven percent of the entries also contained some sort of claim. This

percentage of claims is the lowest of the three students analyzed from this class. In 3% of the entries she included some sort of evidence aligned to the content and in 20% of the entries she included an explanation aligned to the content. The content was represented through pictures in four of the entries, such as that of the beetle (Figure 23) but was usually represented through writing, such as “When I puted my finger in front of the syringe’s tip. I was hard to push or pull the plunger. It’s like if ye you were being pusted by the wind it’s hard to walk. That’s called: air risistance!” (Figure 24) The correct spelling of “syringe” and “plunger,” while incorrectly spelling “pushed” may be a result of having those words on the vocabulary cards at the tables. In the following entry she provided a claim supported by an explanation, “the mealworm and waxworm are difrrent because the waxworm has 12 lines and The mealworm has 16 Lines. Also the mealworm is brown and the waxworm is white.” (Figure 25) In this entry, her use of “because” is evident, as it was in 17% of her entries.

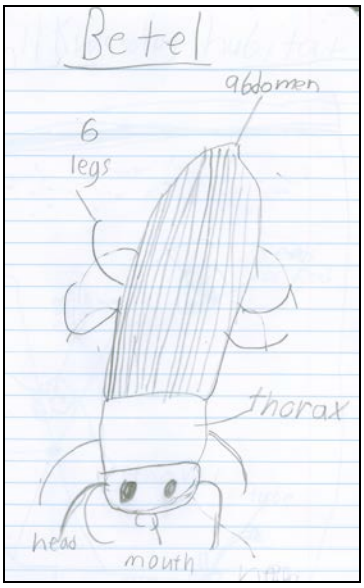

Figure 23. Example of content represented in a drawing, student E3.

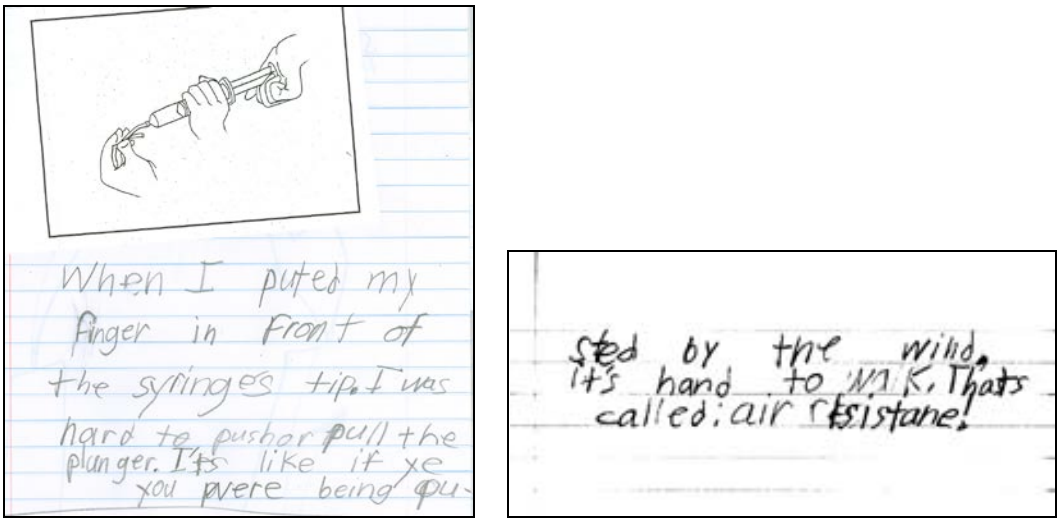

Figure 24. Example of content represented in writing, student E3.

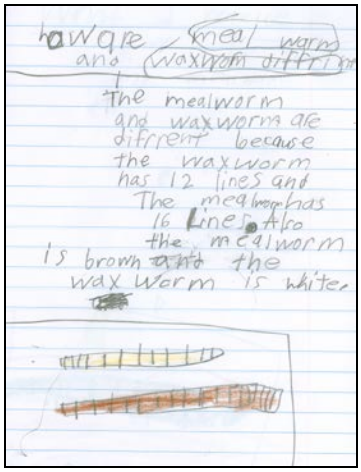

Figure 25. Example of an entry containing a claim and explanation, student E3.

In the interview, E3 talked about how she used a graphic organizer to compare and contrast a mealworm and waxworm before writing the above example.

> … first we wrote about our same thing and then we, then we did a box and then we put the word same on top. Then we write everything that is the same in the middle. And then the next thing is it's a T-chart. Then we, then we know we can do, we can compare and contrast it and that's more easier and this is what we mostly do. (turned to comparison of mealworm/waxworm) This is when we start, when we stop with our explore, class exploration thing, and this is what we write. First we do a writing to talk about what's the same about them. And the other one is the one we really work on it's the one that we write how they are different. And then our teacher tells us that write more, write many things, many things about things.

Within this explanation, E3 referred to the teacher and how she guided notebook entries. Throughout the interview she made many references to how the teacher helped her, including,

> First we start exploring, then in the end our teacher says write in our science notebooks and write the best you can and write everything you think that, that tells you what you learned about and things you can understand.

In addition, E3 also talked about explicit ways in which Elizabeth helped the class, such as, leading them in a scientific drawing to help them make their drawings look exactly like what they saw or having them answer a specific question related to an exploration they just did. When asked why she recorded information in her science notebook, E3 stated that she could look at her science notebook and "remember the answer." In explaining why her notebook was important, she referred to doing what scientists do because "scientists … write about their theories … and sometimes they write in journals like us." While she did not echo Elizabeth's ideas directly, it is evident that she sees the notebook as a tool where she can record her ideas in order to help her with her learning.

Overall, Elizabeth's students included content within their notebooks and focused on explaining their thinking using the word "because," something Elizabeth emphasized throughout her lessons. While her students demonstrated growth in their understanding of the scientific content, the majority of students struggled to covey a strong understanding of the big ideas; which might be a result of the high level of scaffolding Elizabeth provided focused on what to record rather than how or why.

Summary of Elizabeth.

Elizabeth's beliefs and practices towards science and writing in science changed over the years she was at Jones ES and most likely since she joined the study group. She moved from doing activity based science, in which students recorded what they did in their science notebooks but never looked at it again, to content driven science, in which students recorded their understandings. To help promote this focus on understanding, Elizabeth stressed the use of the word "because" in her students' entries and brought up the importance of it within the study group.

She joined the study group as a result of hearing others talk about the success they were experiencing with science notebooks in their classrooms, but not feeling that same level of success in her own. Elizabeth was an active participant of the study group for two years, taking several ideas back to her classroom, sharing outcomes with the group, and pushing important ideas within group discussions. This provided her with a purpose for notebooks and the strategies to implement them within her classroom. Although she had this new purpose, and utilized notebooks more as a learning tool than she had in the past, she still held onto some mechanical aspects. These included a focus on basic elements, such as directing the title for a page; a belief that correct grammar within the notebook was important; and the practice of having students read their recordings, rather than using the information for a meaningful closure to the lesson. While she was more focused on helping students record content over activity and providing them with various strategies to do this, the experiences she provided were highly structured. All of these denote a difference between her practices and those demonstrated in Megan's classroom. Through this direction her students incorporated components of conclusions within their

notebooks, but they struggled to clearly articulate their scientific understandings related to the big ideas of the unit as well as the purpose of a science notebook, unlike Megan's students.

Annie

Annie, a white female, taught first and second grade for the past 11 years, with the last six at Jones ES. The majority of her experience was in first grade with this being her second year of teaching second grade, although her first experience had been 10 years earlier. Due to her prior experience and the gap between her second grade teaching experiences, she felt as though she did not have a strong understanding of the unit she was teaching, which she felt was reflected in her students' learning. When asked about her own experiences with science, Annie stated that she didn't remember much from elementary school because she was a military child and moved a great deal. Her memories went back to high school, where she remembered science being hands-on and enjoying it, although she did state that her experiences were not that impactful.

Annie's learning preference is social, as she referenced talking or working with others as having a strong influence on her own learning. In the interviews, she mentioned several times that she had sought the advice of her grade level peers, who had taught this unit before, in order to learn what might work best for teaching a particular concept. She also referenced the idea that she learns best by watching someone else teach a lesson, because she can see how that person incorporates things and how they implement the curriculum. She talked specifically about two events where she watched another teacher implement the science curriculum and how much she took away from those experiences. The opportunity to learn from others was part of what led her to join the science notebook

study group that year. She stated that she was dissatisfied with the way she was implementing notebooks and wanted to improve her practice.

Initial beliefs and practices.

Annie remembers liking science and getting to experience a hands-on approach to science, providing her with a base to draw from when teaching her own students, unlike Megan and Elizabeth who remembered directed teaching and books. Prior to coming to Jones ES, Annie taught at a school that utilized the FOSS science curriculum, but science was not a priority, and teachers would pick and choose activities from the curriculum. When asked about her views of science, she referred to the importance the school placed on science, but stated that if she were to leave the school she would still try and teach science. It was also clear that she did not feel as though science was her strength, but she taught it, as she believed it was important to do so at this school.

Science notebooks were new to Annie upon coming to Jones ES, and again when asked about their importance, she referred to the emphasis the school placed upon using them. She described them as:

> A way for [students] to keep track of what they've learned … what they did in the experiment. … It's their own personal narrative of what they did in science and they can put their illustrations in there, and it's their own thing. (Initial Interview)

She also described how she started science notebooks at the beginning of that school year, prior to joining the study group as, "At the beginning of the year we do the class notebook, we talk about the type, the date, the heading, it needs a title, and if you're doing a diagram it needs to include labels" (Initial Interview). It is similar to how Elizabeth described the way in which she first used notebooks as well.

It is important to note that Annie had not developed her own views of science and science notebooks, but instead referred to the schools focus on these topics. She focused on mechanical aspects of the notebook, typical of someone at the beginning stages of notebook use.

Influences of the study group.

Annie joined the study group in 2010 and attended regularly during that time frame; she was present at all four of the videotaped study group meetings. During these meetings she entered the conversation minimally, contributing one idea in both January and February, five ideas in March, and two ideas in May. This is in stark contrast to Elizabeth who contributed at least five ideas at each meeting. Annie did discuss the readings, ideas she had tried in her classroom, and struggles she was encountering. At the January meeting, she focused on the frames Fulwiler (2007) provided in her book:

> I really liked the frames... The very simple one, "I predict _____ because _____." Because a lot of kids will say, you know, I think this is going to happen and they don't finish it up with because. They just, I think this is going to happen and they don't tell you the because, and so this simple frame. But, I like how it goes into the more different ones, you know the ones later on where it shows the, "I noticed…" "My evidence is…"

She went on to share that she liked the idea of having students use sentence frames to prompt their thinking and that she had these posted on the wall in her classroom for students to reference. After attending a kit-based workshop from the school district, she explained how they had talked about including a table of contents and glossary in the notebook, but did not indicate if she was going to try and implement either of these within her students' notebooks. She also discussed issues with which she was struggling; such as time constraints and students' ability to communicate their ideas better verbally than they could in writing, as in this excerpt from the March discussion:

Annie	What I found was a good strategy was, my kids love to talk about science, but they don't like to write about it.
Others	Yeah
Annie	I don't know how to explain it, and it's hard, I can't get them to write about it. They can tell you all kinds of stuff about what we're doing and why it's doing it, but then you tell them to write and it's like … I need to get my kids to write more, I mean I know that's a problem, I just don't know how to get them to get more in their notebooks.

In the final meeting, she commented, "This has helped me for next year, I will be able to get more out of notebooks than I was able to this year."

Annie had joined the study group because she was not happy with her students' notebooks and she wanted to be able to get more out of them. In the initial interview she shared that she had implemented various ideas from the study group within her classroom. Like the others, she used a class notebook with her students in order to model entries. In addition she described how she implemented the idea of sharing anonymous notebooks:

> I've actually taken notebooks from other teachers to show my kids what other students in the grade level are doing in their notebooks so that they can see, because sometimes if they only see what's around them they are limited. They think they should only be doing what they see, and so maybe seeing somebody doing a lot more will help them understand that it can be used in different ways.

She also utilized the sentence starters and posted those on the wall for her students to access, as she explained in the March meeting "We have three prompts, I observed, I noticed, I see … up on the wall." Another strategy she discussed in an interview was using the focus question and having them typed out for students to be able to glue them into their notebooks, so they would have the question, and could focus on the content when answering the question. Finally, in the final interview she talked about providing

time for whole group discussions, based on a discussion that had taken place in the study group:

> First, we would have a conversation, because it seems to help if we talk about it first, about what we want, and then go back to their seats and they are able to write a little bit more about it because they heard other people's ideas about it.

In the interviews, she stated that she learned best from seeing someone else implement an idea, which likely impacted what she was able to take from the study group as well. The main idea she talked about gaining from the study group was seeing others' notebooks and what types of information they had in them, as this made her realize that the writing in her students' notebooks needed to be more precise if they were expected to use it as a tool. In addition, she stated that the study group was helping her establish expectations of science notebooks at the second grade level, as she felt that the expectations for first graders were different.

Annie was learning very concrete ideas that she could implement in her classroom, as a result of participating in the study group. In contrast, while Elizabeth and Megan took concrete ideas away, they were beginning to think about more abstract ideas, such as using the notebook as a tool and allowing it to inform their instruction. This seemed to match Annie's learning style, which could be described as concrete. Although the study group was influencing her practices, it did not seem to be causing her to reflect on her beliefs, as Megan and Elizabeth did.

Struggles.

Even though Annie received support from her peers, she shared many struggles and challenges through out this unit. Some of these struggles stemmed from her feelings of inexperience with the unit while other challenges were similar to those experienced by

the other two teachers. Dissatisfaction with the notebooks pushed her to join the science notebook study group, but it continued to frustrate her as she taught this unit, as she explained in the mid-interview,

> I know the importance of the science notebooks it's just, I don't know, I'm struggling with them and [the students] are struggling with them. And I think because it's difficult for me to out where to fit it in this unit that my kids are struggling.

That feeling of trying to it out extended beyond the notebooks to the entire unit as Annie described it as,

> The hardest part was I've never done this kit before, so … not [knowing] what I'm trying to get them to understand out of the whole unit, like what they needed to get out of it and not knowing how to make it easier for them to understand … was a big challenge. (Final Interview)

Annie also felt that the content of this unit was difficult to understand and this presented a challenge for her students, as they would be very involved in the exploration but then struggled to write about it. Annie was not alone in this struggle to get her students to write though, as the other teachers experienced this as well. Like the others too, Annie stated that she did not feel as though this unit lent itself to a great deal of writing and that her students had a much easier time talking about the content than they did writing about it. Finally, like the others, she also stated in the initial interview that time was a factor "because I think they need a good 20 to 30 minutes for writing, where it's hard to do that in the block of time that I have set aside for science."

Annie was very focused on low level concerns, which aligned with the concrete strategies she was seeking from the study group. Her concerns with how to implement the science curriculum and her beliefs about her students' abilities overshadowed her

concerns for the science notebook. Such concerns make it difficult for her to be open to learning new ideas.

Current beliefs and practices.

While she does not feel that science is one of her strengths, she does not avoid it, and believes that science is something that all ELL students can do and makes them "feel like they are all equal" (Mid-interview). In addition she stated that science provides a common, hands-on experience that the students can talk and write about in order to build understanding. She believes the teacher plays an important role in guiding the students in what needs to be done and learned. In the final interview, she described what she thinks good science teaching looks like:

> … good science teaching looks like students that are engaged and excited and they're talking amongst each other and using scientific vocabulary when they're talking. They're coming up with questions about what they're doing, and they're asking questions and posing questions to each other and trying to answer them.

In teaching science, Annie focuses on keeping the students engaged and describes her role as a guide who "show[s] them what needs to be done and what they need to learn." The hands-on component of science is very important for her students, as Annie believes this supports their learning. When talking about the science, she mentioned the activities students would work on, such as observing the insects, building a tower, and shaking the bottles. She stated that her students would get so involved with the activity that they often found it difficult to stop and write.

Annie believes that learning is a social practice both for her students and herself. In the interviews, she stated that she provides time for her students to talk prior to writing, as she thinks writing "needs to take place after the group conversation, because it's easier

for them to say it and then they're able to write it, but if they never say it they can't write it for some reason" (Final Interview). She believes that hearing other's ideas during these group conversations serves as a confirmation to students' own thinking and helps them write more about the topic. She also believes that allowing her students to see what others are doing in their notebooks influences the way her students record.

Beliefs about science notebooks.

Science notebooks were new to Annie when she came to Jones ES, and while she believes they are important, she still struggles with how to implement them. On the survey, she marked that she is comfortable with instructing students in how to use the notebook, but she is uncomfortable in using one herself. While she keeps a class notebook based on the work her students are doing, she does not keep a personal notebook. The discomfort she feels may stem from not yet having a clearly defined purpose for the notebook. During the final interview, she stated one purpose as a way to keep track of information, saying, that students "should be writing about what they're noticing and their questions in their notebook." Annie made several references to the science notebook as a place to record observations and feels this type of recording is easiest for her students, as she explained in the mid-interview, "When we did the insect unit, I think that was a lot easier for them because they could write about what they were seeing and noticing about the insects and what the insects were doing."

Beyond what should go in the notebook, Annie also referenced the purpose of using the notebook as a tool, "I know it's important … for them to be able to go back to their notebook and use it as a reference tool, … and I think that will help them understand why it is so important" (Final Interview). This concept of using the notebook as a tool, came

about as the result of observing another teacher, and may not be fully developed yet. This is different from Megan and Elizabeth who both talked clearly about the notebook as a tool and how this helped students. Finally, she sees the classroom notebooks as different from the notebooks real scientists use, as she stated in the final interview,

> I want to find some real scientific notebooks and show the kids how they're used, because they've never seen a real one; they've only seen the ones we do, you know the class one. But [I want to] show them a real scientific notebook so they can see what real scientists do … this is what scientists do, this is a real notebook and this is how they use it.

Annie believes that writing is a means for her students to communicate what they have learned and that it helps her ELL students develop their language. On the survey she agreed that science notebooks are important, however, she also marked that she feels neutral about writing and language being an integral part of science. When asked to share her thoughts about writing in science, she stated in the final interview, "Since we're a scientific inquiry school, it's an important part of the science piece." When describing what she thinks should be in a notebook in the final interview, she stated,

> They have to write about what they've learned, from doing it. Not necessarily the steps or anything or the equipment that was involved but what they learned from it. I think that's hard for them because they want to write the steps that were involved and what they did to get … to do what ever it was going to do. But I think they don't understand that you can use it as just what I learned from it.

In addition, Annie indicated on the survey that she believes that notebooks should contain claims, evidence, and explanations along with the observations, procedures, and reflections. She also believes that notebooks should be used both during and after an investigation, but does not think that students are as comfortable using it after the investigation as they are using it during the investigation.

To help her students learn how to use the notebook, she believes that modeling is important and stated in the initial interview, “I think it helps the students, um, if they have a visual of, what a good notebook entry is.” In addition to modeling through a class notebook, Annie has used other students’ notebooks as models too. During this unit, Annie decided to have her students use a separate notebook from the one they had used earlier in the year, as she thought it would be easier for them and further their understanding if “they were not flipping all the way through their science notebook trying to get to this unit because that seems to waste a lot of time for them” (Mid-interview). Despite the struggles Annie has experienced with notebooks, she feels as though her students like the notebooks.

Annie’s struggle to clearly articulate her beliefs about notebooks also came through in her goals for her students’ use of them. In the mid-interview Annie stated, “I think my main goal is to get them to use [the notebook] as a… a tool for writing down their wonderings and their noticings, their observations I guess. And, um, any big ideas that they learned from the unit that we are working on.” The main focus in the lessons appeared to be on the idea of having students write down their observations, as evidenced in these statements made to the class on May 31: “You are going to use your science notebook to write down what you are noticing while you are doing the experiments” and “make sure you are writing what you are noticing as you move it from container to container.” After an investigation, she would focus their writing on different aspects with statements such as, “We are going to write about what happened, what we noticed happened when we rolled it, when we shook it, and why we think it happened okay” on June 2 or “you need to get out your science notebooks and you are going to write about

how you separated the mix" on June 1. These goals focus more on the mechanical aspects of the notebook rather than the content of the science, as Megan and Elizabeth had stated.

The changes Annie experienced were subtle. She moved from using the science notebook to keep track of what was done to using it to write about what they learned from doing the science activity. As stated earlier, she was more concerned with implementation and was most likely not ready to think about a set of beliefs very different from her own.

Practices

Unlike Megan and Elizabeth, Annie stated several times that she was unfamiliar with this science unit, which would have an impact on her teaching and students' learning. For the science content, Annie stated the goals, on which she wanted her students to focus, in a couple of different ways. In the mid-interview, she stated that for solid objects, she wanted her students to understand the properties of the solids, and for liquid objects, she wanted her students to know that "liquids do not have a shape, they take the shape of the container." In the final interview though, she stated, "The major goal was trying to get them to notice that solids keep their shape and liquids do not." These goals ended up being difficult for her students, as demonstrated in this exchange that took place during a lesson on June 1.

Student 1	I think it is solid because, because, um, because they are not … they are not liquid because, because they're not like water and kind of like moving around.
Teacher	Okay because the rice moves around? So, you think they're solid because they're not like liquids they're not like water.

Student 2	I think two are liquid because two of them go everywhere and the rest of them don't.
Teacher	Okay you can come up and show me which two you think are liquid and pull them out.

(Student 2 pulled out Rice and Cornmeal)

Teacher	Okay, so you're saying you think the rice and the cornmeal are liquids because…
Student 2	They go everywhere
Teacher	Okay, they go everywhere. And how come you think these are solids then?
Student 2	Because if you put them in a pile they don't move.
Teacher	Okay, so you said if you put these in a pile they don't move. (T put some lima beans in a pile on the floor) So you made a pile. Did they move? … Ah, okay. Who else has another idea if they think these are solids or liquids.

This exchange demonstrated the closest students got to an understanding that solids have their own shape while liquids take the shape of the container. Beyond the big ideas, in the final interview Annie also stated a personal goal related to the activities in the unit saying, "My main goal was trying to get to Bits and Pieces," the third investigation in the science unit where students had to use their knowledge about solids and liquids to determine if small solid pieces, such as rice and cornmeal, were solids or liquids.

Annie also believes it is her responsibility to guide her students towards what they need to be able to do and learn in second grade, including the use of science notebooks. Science notebooks were evident in all seven lessons videotaped for this study, with students using them both during and after an investigation and reading from them during sharing periods at the end of science. While they were present in all videos, there were times when Annie directed students to leave their notebooks at their seats, such as while

they were working to separate a mixture of small solids and when they held discussions on the floor prior to writing. Annie made no reference of the purpose of a notebook to the students but did reference how students should be using the notebook, such as these examples from the lesson on May 31, "you are going to have your science notebooks with you and as you are investigating, you are going to use your science notebook to write down what you are noticing" and "Make sure you are writing as you are doing your experiment." She also provided guidance on including the basic elements of a notebook during a lesson on June 1, such as, "Go ahead and write your date at the top" and "I'm going to write soup mix on the board because that is the title for the lesson we are doing, soup mix." These directions guided her students' recording, but were different from Megan's and Elizabeth's in that Annie focused her students on their observations rather than their thinking.

In addition to verbal reminders, Annie utilized various strategies to support her students. In each of the lessons, she provided students with a focus question to help them structure their writing. These questions included: "Are these materials solids or liquids?" "How did you separate the mix?" and "How are the liquids in the bottle different than the solids in the bottle? How are they the same as the liquids?" In addition to the focus questions, Annie verbally provided students with a structure they might use to answer a question, "You can write, I believe these materials are solids because … or, I believe these materials are liquids because …" This is different from Elizabeth who provided her frames in a written format. Finally, due to the fact that Annie thought her students struggled with writing, she encouraged them to talk about their ideas prior to writing and during the writing time as well, as seen in this example,

> Okay, I see some of us are struggling with the writing part. So, let's go ahead and meet on the floor in a big circle … and talk about it. Leave your science notebooks at your seat … let's have a conversation about what we did, because it is always easier to write after we have talked about it. (Lesson, June 1)

While this may sound similar to Megan's "science talk" it is distinctly different in that she focused the talk on "what we did" where as Megan focused the talk on what was learned.

Although Annie thought her students struggled with writing, she allocated 18% of her science lesson time to writing in the notebook; although it should be noted that some groups were still working with materials during this dedicated writing time. This time usually followed a conversation about the activity that had just been completed. In addition to having her students talk about what they had done prior to writing, she also ended each investigation by having students read from their notebooks in order to share their thinking with others. During this time, students would pass the microphone around the circle and read aloud from their notebook if they chose.

Annie's main focus remained on tangible ideas she could see and easily implement, making for a subtle shift in the way in which she understood notebooks and implemented them in her classroom. This was different from Elizabeth and Megan who had moved on to thinking about notebooks in a more abstract manner. In addition, Megan implemented practices that pushed her students to think about notebooks in a more abstract manner as well. Annie's concrete style and concerns for implementation most likely prevented her from making bigger shifts in her practice.

Student outcomes.

Student outcomes are presented on three different levels. First class results of the pre- posttest for the solids and liquids unit of study are examined. Second, results from a content analysis of the science notebook entries for 18 of the 19 students in the class are presented. Finally, three students' notebooks are examined in greater depth, looking more closely at their understandings based on their interviews, posttest results, and a content and taxonomic analysis of their science notebooks over the year. Examples of all student work are direct quotes, including spelling and grammar, from the original documents.

Class results of pre / posttests.

Annie's students showed growth in their understandings of solids and liquids over the course of the unit, however, some struggled to clearly articulate these ideas by the end of the unit as demonstrated on the pre- posttests. Table 7 shows the results of the pre- and posttests for the unit on solids and liquids.

Table 7

Percent of Students Scoring Within Point Ranges On Pre- and Post-tests – Annie's Class

Type of test	Point range	% of students	
		Pretest	Posttest
Performance (out of 12 points)	12-10	0	0
	9-7	25	61
	6-4	69	33
	3-0	6	6
Written (out of 9 points)	9-8	6	0
	7-6	6	33
	5-4	19	55
	3-2	56	6
	1-0	13	6

Twenty-five percent of her students scored above 50% on the performance pretest, while 61% scored above 50% on the posttest. A typical response on the pretest to whether a crayon was a solid or a liquid was "I think the crayon is a solid because it could color." Students typically referred to some characteristic of the crayon to support their thinking about why it was a solid, earning them two points for this question. On the posttest though, many students referred to the properties of solids they had learned and a typical response was, "I think that the crayone is a solid because it is regid smoth and it is hard." This type of answer earned them three points for this question. None of the students in this class scored the maximum of four points on this question, as they did not include the big idea that a solid maintains its shape. This also meant that none of the students scored above 75% on the posttest.

On the written pretest, 12% of Annie's students scored at least six out of nine points, while on the posttest, 33% scored in this same category. On this test, students had to correctly identify a solid and a liquid through a drawing, of which most could do, and they were asked to write a written response to the question "How are solids and liquids different?" Many students struggled with this on the pretest and scored zero points for this question. A typical response was, "thay are different solid and liquid are not the same as solid an liquind". On the posttest, most of the students answered this question by providing an example of a solid or a liquid, such as, "Thare different because Liquids are all waters and solids are not water." This type of response earned them one point on this question. In order to earn the maximum four points, students needed to restate the big idea that solids have their own shape while liquids take the shape of the container. None

of the students in this class were able to articulate this level of understanding in their response.

Science notebooks.

Annie taught a total of six lessons, during which her 18 students created 72 notebook entries. These entries were analyzed through content analysis and results are presented as percentages in Table 8.

Table 8

Percentage of Science Notebook Entries Containing Various Elements – Annie's Class

Notebook Elements	% of Entries
Basic Elements	
Date	88
Title	33
Focus Question	3
Drawings / Diagrams	0
Labels	0
Writing	100
Graphic Organizer	0
Content of Entries	
Addresses Science Content	33
Describes Science Activity	22
Describes Feelings	0
Contains a Claim	74
Contains Evidence	13
Contains an Explanation	19
Uses "because"	29

Of the entries examined, 33% of them focused on content. The use of a claim was evident in 74% of the entries, 13% contained evidence that was aligned with a claim, and 19% contained an explanation that supported the claim that was made. An example of a conclusion, or all three parts, included: "I think that the materials are solids because thay can make a pile like a peramid cind of and it dosnt go all over the place like a big glob like a swimming pool." (Figure 26) The majority of the claims made focused on

describing a material, such as “I noticed that the cornmeal moves fast and some kind of stae in the countaner.” (Figure 27)

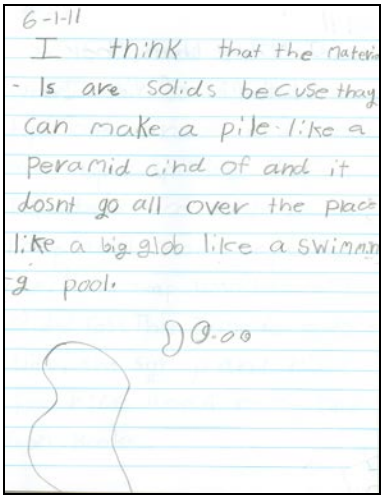

Figure 26. Example of an entry that contained a conclusion, student A10.

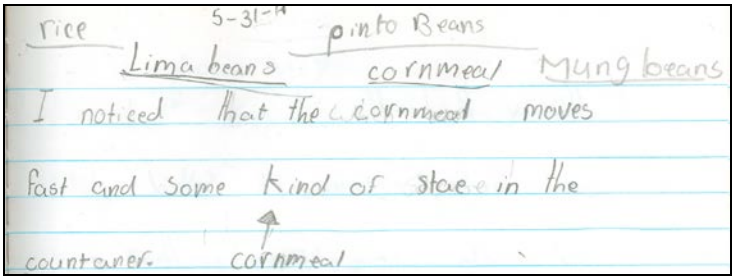

Figure 27. Example of an entry that describes the material, student A16.

Deeper analysis of three students.

Three students were interviewed and notebook entries over the course of the year were analyzed. The first 10 entries from each of the three science units were analyzed using content analysis and results are presented as percentages in Table 9. Student A1 had lost her original notebook from the beginning of the year and so she did not have any entries from the unit on insects to examine, therefore, a total of 20 entries were analyzed for her.

Table 9

Percentage of Science Notebooks Containing Various Elements – Individual Students from Annie's Class

Notebook Elements	A1	A2	A3
Basic Elements			
Date	85	97	100
Title	30	30	67
Focus Question	5	3	3
Drawings / Diagrams	10	37	47
Labels	10	17	40
Something Glued in	45	30	30
Writing	65	77	77
Graphic Organizer	0	0	7
Content of Entries			
Addresses Science Content	15	60	53
Describes Science Activity	15	27	20
Describes Feelings	0	0	3
Contains a Claim	0	7	23
Contains Evidence	0	0	3
Contains an Explanation	0	7	13
Uses "because"	5	7	23
Entry Appears Incomplete	20	7	37

A1.

Student A1 was not able to clearly articulate the big ideas of solids and liquids. In the final interview, she stated that "some roll, um, fast, and some roll, some roll slow." This is similar to what she recorded on her written posttest, "becus solids muve slow liquids muve fast." She also struggled with these ideas on the performance posttest, as she described the crayon as, "That that the coulr has the name of the coulr it sas with becus i now wat is a solid it looks like a solid." In describing soil, she referred back to the idea of movement, "I now that is drt i thenk that's a solid. I thenk that's a solid becus it muvs

slow." Unfortunately, she was absent on the day of the pretest and did not take it upon her return, so there is no way to know what she understood prior to this unit.

Within her notebook, she tended to describe what she was doing or the properties of the materials with which she was working, such as, "cornmeal fils like sand bech sand and it asoe fils lik roks and it has calr the culr is yellow" (Figure 28); as this is what Annie emphasized to students. It should not be surprising then that only 15% of her entries addressed the content being studied and that none of her entries contained a claim, evidence, or an explanation. In addition it appeared as though 20% of her entries were incomplete.

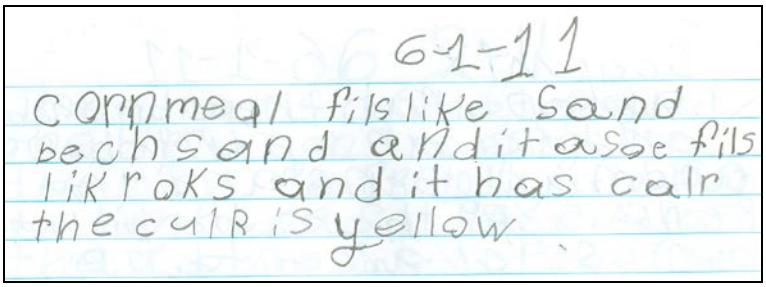

Figure 28. Typical entry describing the material, student A1.

Student A1 had a weak understanding of the purpose of a notebook. She stated that she records "stuff that we do in science" in her notebook "so [she] could remember what it is." When asked to elaborate on a page, she stated, "We had to take like the stuff we saw … we had to do write about them, what we notice about them." This is similar to how she believes scientists use a science notebook, as she stated, they "write on it … science stuff." When asked why she included or did not include some information she responded, "Because the teacher didn't tell us" or "Because the teacher tells us." She also stated that the teacher helps her with her notebook by helping her spell words and "telling us to put the date." She does see the date and writing as important components of

her notebook, and these were present in the majority of her entries. Again, this was an area Annie emphasized.

A2.

Student A2 used the properties of solids and liquids to define the differences between them. In the final interview he stated, "They have different things … Like a liquid has a viscous and foamy and a solid has like flexible and, and like a shape." His final statement leads to the bigger concept that solids have a definite shape, but when asked how he knows if something is a solid or a liquid, he responded that he looks at how it feels and smells. Furthermore on his written posttest, he wrote, "Solids and liquids ar different becase solids is not foumy and bubluly and viscouse and liquids are not flexivo." This response was an improvement from his pretest, in which he wrote, "One is juis and the ador wan is somting you can ahou onet." While he moved from defining solids and liquids by examples to properties they hold, he could not clearly articulate that solids have a definite shape while liquids take the shape of the container. His responses on the performance pretest and posttest were similar to those above as well, as he described lotion. On the pretest, he wrote, "the lochen is liquid decause is lik I juice." and on the posttest he wrote, "it is a liquid because is viscouse and is foamy."

Within his notebook entries, while 60% addressed the content being studied, only 7% of his entries had a claim or explanation within them. He did not include any evidence to support his claims. Although he had a limited number of claims, he did show growth in his language from the first claim to the second claim. His first claim from *Insects* read, "the waxworm is drefen oye miolworm. Wat deit." (Figure 29) His second claim from *Air and Weather* read, "I noticed that wend I prest the plunger and then water come otu of

the plati bottle and the air go down the plastic bottle”(Figure 30). His explanations were connected to other entries in which he did not make a claim, but provided an explanation of why he did something, such as, “I put I cup at the vorom because i was rond and the cup was hard and it can cery ebriting.” (Figure 31)

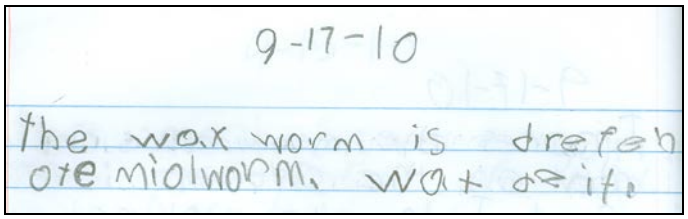

Figure 29. Example of a claim early in the year, student A2.

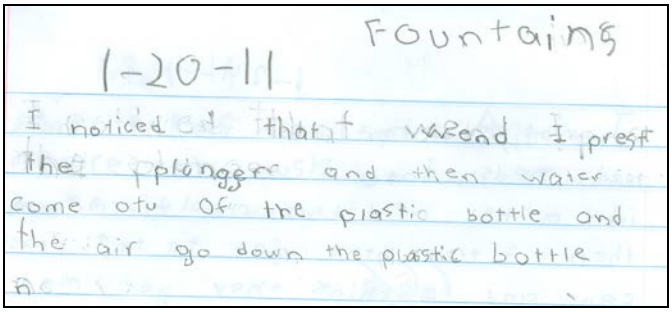

Figure 30. Example of a claim, midyear, student A2.

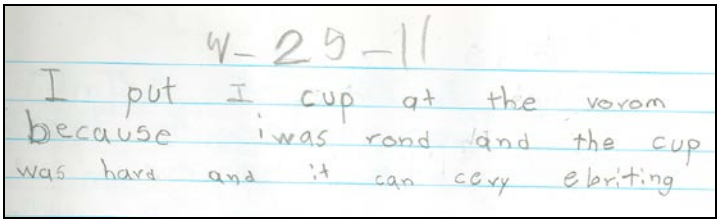

Figure 31. Example of an explanation, student A2.

A2 believed the date was an important component of his notebook, as he stated in the interviews several times and demonstrated in his notebook by including it in 97% of his entries. He understood that the date would help him know when he had done something. In the interview, he also stated that some parts of his notebook, such as a title and words on the page, helped others know about what he was writing. He stated that science notebooks are important for both him and scientists for similar reasons. For him, it is important for writing “our stuff of what we know” and for the scientists to “write the

things that they know." In determining what to write, he looks to the teacher for direction, as he stated that she helps him by telling him to write the date on his page or that his teacher helps him know what to put in his notebook by telling the class to "draw a picture" or "by [my teacher] telling about things and I remembered in my mind and then I put them in my science notebook." He believes the science notebook is important but stated that writing in the notebook is his least favorite part about science.

A3.

Student A3 could not clearly articulate the idea that a solid has a shape while a liquid takes the shape of the container. She came close at one point in the final interview when she reread an incomplete entry on small solids and stated, "I was going to write if, if it was a liquid it would be like, like if we dump it, it would spread around." However, she did not make any reference to this idea when asked specifically to describe the differences between solids and liquids. She stated, "they have different kinds of properties like, like, um, viscous, transparent, translucent, and like the solids have like rigid, smooth, rough and all those things." This response is similar to the responses she put on her tests. On the written pretest, she described the differences through examples, and wrote, "Solid is different from liquid because liquid is watery and solid is not watery." On the written posttest, she referred to the difference in properties but did not give specific examples of properties. Her response, "Solids and liquids are different because both solid and liquid have different propertise." On the performance pretest, she described lotion as, "liquid It is liquid because it is liquidy." but on the posttest used properties, "It is a liquid. It is a liquid because it is viscous and translucent and has color. The liquid is cream."

Within her science notebook entries, she addressed the content being studied in 53% of the entries analyzed and made claims aligned to the content in 23% of the entries. She supported her claim with evidence in 3% of the entries and provided an explanation aligned to the claim in 13% of her entries. Her entry that contained these three elements focused on an air balloon rocket and read, “I think that the rocket is going to launch to the right becaus last time my class did that and my balloon in the bag went to the right. The air moves the bag because the air in the balloon gets out and the air pressure pushes the balloon. I like Science.” (Figure 32) In this example, it is evident that Annie utilized a strategy, discussed in the study group, of providing students with a visual prompt from the science curriculum materials. A3 wrote a great deal in her science notebook and used words to record with in 77% of her entries. While she was adept at writing, when asked in the interview why she didn’t include some things in an entry, she stated, “I was about to like draw a picture … but then like we had to go to the other station.” It appeared as though 37% of her entries were incomplete.

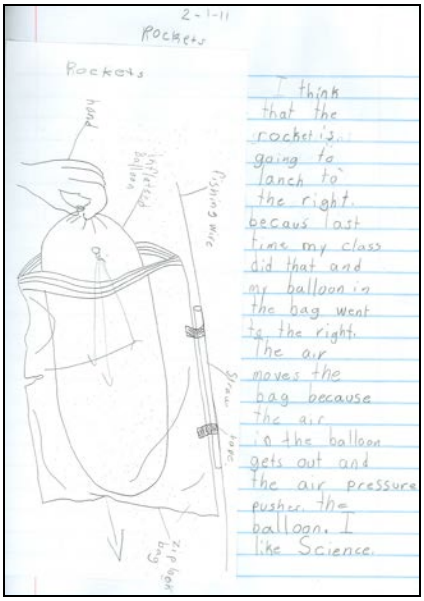

Figure 32. Example of an entry that contained all part of a conclusion, student A3.

A3 likes science and enjoys writing about science. When asked what kinds of things she put in her science notebook, she focused on observations and said that she writes about what she observes or draws a picture and labels it. She stated that labels were the most important part of one of her entries and that without them people wouldn't understand her drawing. When asked how scientists use a science notebook, she again referred to observations, and stated, "when they like observe something, they start to write what they observe." She also stated that her teacher said, "it's a science notebook and we have to write about our observations." She understands that the notebook can be used as a reference and stated that you "could open your science notebook and use it to see what you observed" if the teacher asks you about something or if you forgot something. Overall, she sees her notebook as a place to record her observations, of which 60% of her entries focused.

Overall, Annie's students struggled to convey their understandings about the science concepts they were learning and the purpose of a science notebook. This is reflective of Annie's struggles with the content and purpose of a science notebook, which were also somewhat undeveloped. Annie's focus on concrete strategies she could implement most likely influenced her students' abilities to utilize the notebook to develop deeper conceptual understandings.

Summary of Annie.

Annie joined the science notebook study group that year because she felt as though her students' notebooks could be better, but she was unsure of how to get them there. It was evident that she was still struggling with aspects of the notebook, as well as the content of the science unit, which may have impacted any type of change she experienced

related to science notebooks. The changes she experienced were minimal, and while she stated that notebooks should be focused on learning, she did not put this into practice, as Megan and Elizabeth had done.

While Annie recalled a positive high school experience with hands-on science, it appeared as though she did not have strong beliefs about the importance of science and writing in science. When asked about these items, she referred to the importance her school placed on both of them rather than her own ideas about them. This is in stark contrast to Megan and Elizabeth who both had strong personal ideals about science. In addition, she may have been overwhelmed with teaching a new curriculum, as she stated several times that she was unfamiliar with the curriculum and that she was simply trying to finish. Both of these issues could have impacted the type of change she experienced.

Annie felt these struggles were evident in her students' work as well, as she believed that they could express themselves better verbally then they could in writing. While her students incorporated the elements of a science notebook, including claims, evidence, and explanations, into their entries, their main focus was on recording their observations using words or drawings, which is typical of beginning notebook use. Annie often stressed this focus on observation and a more mechanical use of the notebook, indicating a misalignment between her beliefs and what she was learning about notebooks. Based on this focus on observation and activity within the notebooks, it is not surprising that her students could not clearly articulate their scientific understandings at the end of this unit or a purpose for the science notebook. As a result Annie's students had the lowest outcomes out of the three cases examined.

Cross Case Analysis

To add robustness to the study, a cross case analysis of the three cases was conducted. In this section, I examine similarities and differences between the three cases, looking at backgrounds, influence of the study group, goals for the lessons, beliefs about science notebooks, classroom practices, and student outcomes.

Background

The three participants had similar backgrounds in that teaching science and using science notebooks was fairly new to them upon coming to Jones ES to teach. Each teaches science on a regular basis and believes it is important that their students are exposed to hands-on science experiences using science notebooks. The level of importance each placed on science differs however, in that Megan and Elizabeth talked about science playing a role in all that their students do, such as helping students become thinkers in various content areas, while Annie talked about the role science plays at the school and for her students as English language learners. Such statements make it appear as though Megan and Elizabeth's beliefs about science are more *entrenched* (Keys, 2005) than Annie's beliefs at this point in time. Table 10 compares each teachers' initial ideas concerning science, their beliefs about science notebooks, and their practices to their current ideas.

Table 10

Comparison of Teachers

	Initial			Current		
	Concept of Science	Beliefs	Practices	Concept of Science	Beliefs	Practices
Megan	Teacher delivers information	Reflection focused on what was done	Students write whatever they want	Discovery through hands-on	Tools for learning the content	Guides recording to focus on using it as a tool to learn content
Elizabeth	An activity you do for an hour	Journal of what they did/thought	Informal recording	Learn by doing and talking	For the purpose of learning the content	Guides recording to content and basic elements
Annie	Pick and choose activities	Narrative of what they did in science	Focused students on basic elements	Learn by doing and talking	For the purpose of recording observations	Focused students on basic elements and observations

As each of the participants attempted to refine their own ideas about using science notebooks, they encountered various struggles, which could have played a factor in their level of conceptual change (Pintrich et al., 1993; Posner et al., 1982). Annie expressed concerns related to teaching the curriculum for the first time and trying to incorporate notebooks within the investigations. These types of concerns may impede Annie's ability to implement science notebooks in the reform-based manner intended (Davis et al., 2006), as she was focused on management issues. Elizabeth's struggles extended beyond the difficulties her students encountered to the disequilibrium she was experiencing based

on study group discussions around levels of support and feedback. This disequilibrium demonstrates that the study group was stretching Elizabeth's thinking about notebooks (Pintrich et al., 1993) and that she seriously considered ideas shared in the study group and how she might incorporate them into her classroom. Megan created her own disequilibrium, as she questioned the type of notebooks and entries students needed to keep in order to get the most out of the notebooks. This type of thinking may stem from the pedagogical knowledge she has gained as a result of participating in the study group over an extended period of time (Fernandez, 2005; Levitt, 2002; Supovitz & Turner, 2000). The influence the study group had on all three cases is examined next.

Influence of the Study Group

The study group served as a means for these individuals to learn about notebooks and how to use them in the classroom. All joined at different times, but stated their purpose for joining was that they recognized they were not happy with how they had been using notebooks and wanted to learn more about them, making them open to change (Posner et al., 1982). Each took ideas from the study group and implemented them in her classroom and shared outcomes and strategies she had tried with others in the meetings. However, the impact the study group had upon each of them was different and was most likely tied to the amount of time they had participated and the attitudes and beliefs they held (Duit & Treagust, 2003).

Megan was the only one who credited the study group with helping her develop big ideas about notebooks, such as it being a tool for both the students and her; this aligns with Lave and Wenger's (1991) view that ideas are a product of the situation from which they were learned. While Elizabeth did not recognize the study group as attributing to

her big ideas about science notebooks, she did recognize that the collegiality of the group was causing her to think about her practice and how she could best support students' entries to build towards an understanding of the scientific content (Peers et al., 2003). It was evident during the meetings, that Megan and Elizabeth were not only thinking about their own practice, but were asking others to consider their implementation as well, by pushing the group to question current practices and expectations.

While Annie participated in the meetings, her involvement was at a different level, as she focused her comments more on the book the group was reading and the strategies she had tried in her classroom. The idea that Annie took from the study group was the development of new expectations for what science notebooks could look like in her classroom, based on seeing others' notebooks. As a new member to the group, her concerns were focused more on the management of notebooks and how to engage students than on using the notebooks to develop conceptual understanding (Davis et al., 2006).

Beliefs about Science Notebooks

The teacher's beliefs about science notebooks impacted the manner in which they implemented them within their classrooms. Annie's beliefs about science notebooks were the most immature of the three and demonstrated the least amount of change from when she first started using science notebooks. Annie struggled to clearly articulate a purpose for science notebooks. While, at one point, she stated that they should be focused on learning and serve as tools, she repeatedly referred to them in both the interviews and her lessons as a place in which students should record their observations and wonderings. This suggests that Annie's beliefs about science notebooks were still

developing and not clearly defined at this point. An explanation for this difference may be that while she focused on observations and wonderings, the study group had raised her awareness that notebooks should be about more than observations and activities; they should be tools for students and focus on the science content. This type of conflict in beliefs is common as people are exposed to new ideas (Keys, 2005).

Both Megan and Elizabeth stated that their beliefs about science notebooks had changed over time and that in the beginning they saw them more as journals where students recorded what they wanted. They no longer viewed notebooks in this way and instead talked about how notebook entries needed to focus on the science content rather than the activity. While Elizabeth believed that notebooks were essential to her students' learning and that they should be focused on the content, she continued to focus on the basic elements as well, such as emphasizing correct grammar within the notebooks. Megan had the most well developed belief about science notebooks as learning tools. Not only did she emphasize the importance of content within the notebooks, but she also emphasized in the interviews as well as in her practice how the notebook served as a learning tool. She saw it as a tool not only for her students but for herself as well and believed that it was essential that she examine her students' notebooks if she was going to be able to help them grow.

Goals for the Lessons

Science notebooks.

Megan and Elizabeth both focused on student understandings for goals for the science notebook. Megan wanted students to focus on the content using claims and evidence and for those who struggled with writing to help them get something into their notebooks.

Elizabeth wanted her students to be able to convey their thinking in writing, using the word "because" to help support their thinking. These goals are in alignment with the findings of Choi et al. (2010) who found that science writing should focus on claims and evidence and the relationship between them. Annie's goal for the notebook focused on having students record their observations, which Ruiz-Primo et al. (2004) found did little to further student understandings.

Science content.

While each of the three participants stated similar goals for the science content they wanted their students to learn, they all said it in different ways. Megan wanted her students to define a solid and liquid with evidence, clarifying the definition she wanted for a solid was that they hold their own shape. Elizabeth wanted her students to understand the properties of solids and liquids and that liquids take the shape of the container in which you pour them. Annie stated her goal as understanding the properties of solids and liquids, such that solids keep their shape and liquids do not. However, she also stated that a goal for her was to simply get through the kit, which may suggest that Annie was being challenged cognitively at this point, making any change she was experiencing more difficult (Pintrich et al., 1993). The teacher's understanding of the content is important, as her level of understanding will impact her students' achievement (Brophy, 1986; Hill et al., 2005; Ma, 1999; Shulman, 1986).

Classroom Practices

Since all three participants were new to science notebooks when they came to the school six years ago, they did not have preconceived notions of what science notebooks should look like in the classroom, so they developed their ideas through talking with

others, reading, and professional development. Each of them approached the use of notebooks in very different ways. Table 11 highlights some of the practices from each teacher's classroom.

Table 11

Highlights of Classroom Practices

Megan	Elizabeth	Annie
28 % of lesson time dedicated to writing	16 % of lesson time dedicated to writing	18 % of lesson time dedicated to writing
Referred to the notebook as a tool seven times	Did not refer to the notebook as a tool	Did not refer to the notebook as a tool
Focused students' recordings on the content, how to record, and what to record	Focused students' recordings on basic elements and getting information in the notebook	Focused students' recordings on observations, activity, and basic elements
Science notebooks and writing were present in all lessons	Writing was evident in all lessons although science notebooks were not	Science notebooks were present in all lessons, but students were told to leave them at their seats

In Megan's classroom, notebooks were present in all lessons. She not only directed students on what types of things to record within the notebook, but she reminded students that it was a tool and that they should be using it as such. She placed an emphasis on writing in science by dedicating 28% of the lesson time to writing. While notebooks were not present in all of Elizabeth's lessons, she did include writing in each lesson. She directed students to record information in their notebooks and to include the basic elements, but she did not refer to it as a tool. Elizabeth dedicated the least amount of time to writing in science, at 16%. Science notebooks were present in all of the lessons in Annie's classroom; however, students were directed to leave them at their seats during certain activities. She too reminded students to record information in their notebooks,

focusing mainly on observations, what they were doing, and basic elements. She did not reference it as a tool either. Annie dedicated 18% of her lesson time to writing.

The manner in which all three teachers used and referred to the science notebook throughout their lessons represents their entrenched beliefs, or those they act upon (Keys, 2005). Megan's actions most closely aligned with her stated beliefs. While the other two teachers demonstrated certain aspects of their stated beliefs about notebooks, the idea of a notebook as a tool was not enacted and one could assume this belief is not yet entrenched (Keys, 2005).

All three teachers provided varying amounts of scaffolding, such as focus questions, to support their students writing, although, Elizabeth provided the greatest variety, including a small group writing activity, sentence starters, and vocabulary cards. All of the strategies Elizabeth used had been discussed in the science notebook study group at some point over the two years she had been a member. Both Elizabeth and Annie used sentence starters as a form of scaffolding for their students; however, the manner in which they used it was very different. Elizabeth provided a sentence starter, written out on chart paper, to each small group, who used the starter to compose a conclusion to share with the class. Annie used sentence starters to verbally suggest to students ways in which they might begin their sentence, but she never provided the starter in a written format for students to use. While both used the scaffold of a sentence starter, they did it in very different ways, resulting in different outcomes.

The manner in which each of them chose to implement science notebooks is tied to their pedagogical content knowledge (Shulman, 1986), which Grossman (1990) suggests is learned through apprenticeship of observation (Lortie, 1975), professional coursework,

and experience. Since notebooks were new to each of them upon coming to Jones, it can be assumed that most of their knowledge came from coursework, or professional development, and experience. Ruiz-Primo et al. (2004) found that when teachers relied on their experience, they typically used science notebooks in a more mechanical manner. Although all three teachers incorporated ideas shared during the study group into their instruction of science notebooks, Elizabeth and Megan have had more professional development to draw from. With this being Annie's first year in the professional development she may be relying more on her personal experience at this point in time.

Student Outcomes

In this section, I will compare the student outcomes on three levels: performance on the posttests, content of the science notebooks, and purpose of a science notebook.

Performance on the posttests.

While all classrooms demonstrated student growth over the course of the solids and liquids unit, Megan's students had the strongest understanding of the content being learned as demonstrated in Table 12, which shows the results on the posttests for all three classes.

Table 12

Percent of Students Scoring Within Point Ranges On Posttests

Type of Test	Point Range	% of students		
		Megan's Class	Elizabeth's Class	Annie's Class
Performance (out of 12 points)	12-10	55.5	6	0
	9-7	22.5	72	61
	6-4	16.5	22	33
	3-0	5.5	0	6
Written (out of 9 points)	9-8	55.5	17	0
	7-6	17	49	33
	5-4	22	28	55
	3-2	0	0	6
	1-0	5.5	6	6

Fifty-five point five percent of Megan's students scored in the top point range on both the performance and written posttests. This was much higher than the other two classes, as Elizabeth's class had only 6% on the performance and 17% on the written posttests scoring in this same range, and Annie's class had no one score in this range on either the performance or written posttests. Student understanding is tied to the teacher's understanding (Brophy, 1986; Hill et al., 2005; Ma, 1999; Shulman, 1986). In the interviews, Megan had most clearly articulated what she wanted her students to understand at the end of this unit of study. Her understanding may be due to the fact that she has taught this unit more often than the other two teachers and therefore has a better understanding of the content and curriculum goals, but it may also be tied to the way in which her students recorded information in their notebooks, which will be examined next.

Content of the science notebooks.

Content of the students' notebooks was examined on two different levels. The first level looked at all students' notebook entries for the unit of study on *Bits and Pieces*. The second level looked at the notebook entries of three students from each class, focusing on the first ten entries from each unit of study over the course of that year.

Comparison of students' notebook entries for unit of study, whole class.

During this unit, the three teachers approached use of the notebook in different ways, which resulted in very different outcomes. These outcomes are represented in Table 13.

Table 13

Percentage of Science Notebook Entries Containing Various Elements – Whole Class

Notebook Elements	Megan's Class	Elizabeth's Class	Annie's Class
Basic Elements			
Date	72	95	88
Title	54	100	33
Focus Question	32	49	3
Drawings / Diagrams	5	0	0
Labels	11	0	0
Writing	100	100	100
Graphic Organizer	4	51	0
Content of Entries			
Addresses Science Content	68	86	33
Describes Science Activity	9	14	22
Describes Feelings	0	5	0
Contains a Claim	95	30	74
Contains Evidence	16	5	13
Contains an Explanation	39	22	19
Uses "because"	37	43	29

Elizabeth's students produced the fewest entries throughout this unit of study, with only 37 entries, compared to 57 entries from Megan's students and 72 entries from Annie's students. Within those entries, Elizabeth's students had the highest percentage of entries

containing such basic elements as the date and title, but also had the highest percentage of entries addressing the content being studied at 86%. While this is significant, Ruiz-Primo et al. (2010) found that entries that focus on conclusions, which utilize claims, evidence, and explanations, led to higher student achievement.

In examining the use of claims, evidence, and explanations Megan's students had the highest percentage of these elements represented in their notebooks. This supports Ruiz-Primo et al.'s (2010) findings, in that Megan's students also scored the highest on their posttests. The notebooks from Elizabeth's class had a lower percentage of entries containing claims (30%) and evidence (5%) than those from Annie's class, at 74% and 13% respectively; however, Elizabeth's notebook entries had a higher percentage of the use of "because" at 43% compared to 29% from Annie's class. Throughout her lessons, and as one of her goals, Elizabeth emphasized the use of "because" to her students as a way to explain their thinking, which is building towards the thinking necessary for conclusions. In contrast, Annie focused her students more on their observations, which would allow them to make a claim about something, but she did not push them to explain their thinking to support their claims. Finally, Elizabeth's group writing activity, in which students created a claim supported by evidence and/or an explanation on a group poster rather than in their notebooks, was not counted as a notebook entry, but such a structured activity may have helped Elizabeth's students understand the concept as well.

Comparison of students' notebook entries throughout year, individual students.

In order to compare the data collected from the three students in each class, the number of times each element appeared in the individual notebooks was compiled to

come up with an overall percentage for how often each element was represented in the entries examined over the course of the year. This data is represented in Table 14.

Table 14

Percentage of Science Notebook Entries Containing Various Elements – In-depth Students

Notebook Elements	Megan's Students	Elizabeth's Students	Annie's Students
Basic Elements			
Date	81	56	95
Title	54	47	44
Focus Question	19	17	4
Drawings / Diagrams	38	37	34
Labels	47	16	24
Something Glued in	35	30	34
Writing	72	70	74
Graphic Organizer	19	14	3
Content of Entries			
Addresses Science Content	64	65	46
Describes Science Activity	10	24	21
Describes Feelings	0	4	1
Contains a Claim	42	32	11
Contains Evidence	2	7	1
Contains an Explanation	18	19	8
Uses "because"	29	21	13
Entry Appears Incomplete	12	13	21

When these entries are compiled in this manner, it serves as a lens to see what types of elements students were working with over the course of the year. While the percentage of claims, evidence, and explanations included in entries from Megan's students were not as high over the year as it was during the unit of study, it does imply that such elements were a focus throughout the year and not just for the unit of study. In Elizabeth's class the percentage of claims and evidence was actually higher throughout the year than it was during the unit of study, also indicating that this was a focus in her

classroom throughout the year. However, in Annie's classroom, the percentages of these elements was lower, with claims having the biggest difference with 74% during the unit of study and only 11% throughout the year. This could indicate that Annie focused on a mechanical use of the notebook (Baxter et al., 2001; Ruiz-Primo et al., 2004) throughout the year; that she gained ideas from the study group over the course of the year, changing her pedagogy later in the year; or perhaps the study influenced the manner in which she taught, since she stated in the final interview that one of her goals was for the students to write in their notebooks, as "I know that's part of your study and part of our science notebook writing group after school."

Another element that may factor into overall student understanding is the use of the graphic organizers (Patterson, 2001). Nineteen percent of Megan's entries and 14% of Elizabeth's entries contained some sort of graphic organizer. These entries appeared to be more teacher directed in nature, as there were similarities between students' entries. Using the graphic organizers in this manner may actually help the students organize their thinking and produce written work that closely represents their understandings (Warwick et al., 2003).

Overall, the data from the notebooks supports the findings of Lee et al. (2009) who found that student writing increased in accordance with how long the teachers had received treatment and implemented the program. In this study, Megan was involved in the study group the longest and had the highest percentage of student entries focused on the important elements of a conclusion (Ruiz-Primo et al., 2010).

Purpose of a science notebook.

In looking at the purpose of a science notebook, I talked with the three students from each class to understand what they saw as the reason for keeping a science notebook and what types of information they should include in the notebook. In the science notebook study group, the teachers had talked about the notebook serving as a tool, in which students could look back at information and then use that information in some other manner. In addition, they had discussed the idea that entries should focus on the content. If these beliefs were internalized by the teacher and put into practice in their classrooms, one may expect to find that students begin to develop similar ideas (Green & Dixon, 1994).

All of the teachers expressed a belief that the science notebook was a tool, but only Megan reiterated that explicitly to her students. As such, two of her students described it as "a tool" and stated that information within it could be shared with others. While Annie and Elizabeth stated they viewed the notebook as a tool, they did not explicitly state this to their students. As a result, their students did not use these words, but instead talked about how it helped them remember or helped others understand something. Statements such as these seem to be building towards this idea of the notebook as a tool, and perhaps if the teachers were more explicit (Tucknott & Yore, 1999) this idea could become more embedded in the students' thinking and rationale for a notebook.

Megan's students also talked about the notebook as a place to record "information," with one student stating that it should contain evidence. While the word information is somewhat vague, students from the other classes did not use this word to describe what should be in the notebook, instead they used words such as "writing," "drawings," "what

we do," and "what we observe." The first two convey an understanding of how to record information, but not what to record. When pressed further on what they might record, two students from Annie's class stated that their teacher tells them what to record in their notebook, making it evident that while they know how to record they did not have ownership of what to record. The last two ideas, "what we do" and "what we observe" convey an idea of what to record, but it focuses more on the mechanical elements that were found to not be supportive of using the notebook as a write-to-learn strategy (Baxter et al., 2001; Ruiz-Primo et al., 2004).

Overall, this cross-case analysis suggests that participation in a professional study group can have an impact on a teacher's beliefs and practices, which in turn influences student performance. Furthermore, the data suggests that participation over an extended period of time has a greater impact, as Megan demonstrated well developed beliefs and practices about science notebooks and in turn her students had a better understanding of the scientific content they were learning as well as the purpose of a science notebook. Although Elizabeth's beliefs were not as entrenched as Megan's she was questioning her practice and utilizing strategies to help her students make the most of the science notebooks as learning tools. As a first year participant of the study group, Annie implemented notebooks in a mechanical manner, making small shifts in her teaching to incorporate concrete strategies she had learned about in the study group. While her beliefs had not yet shifted, these small shifts in her practice imply that the study group was having an impact on her use of science notebooks. Based on these results, a substantive theory was formed that examines the progression of science notebook

implementation from mechanical use to insightful use. This substantive theory is explained in the next chapter.

Summary

The purpose of this chapter was to develop the cases for each individual to demonstrate how their beliefs, practices, and student outcomes were impacted by their participation in a study group on science notebooks. Before building these cases, the study group was presented, sharing the history of the group and themes that emerged within the meetings that took place during this study. Then each case was developed to explore the teacher's background, initial beliefs and practices, the influence she perceived the study group to have had on her beliefs and practices, her current beliefs and practices about science notebooks, the change in beliefs and practices, and finally her students' outcomes related to development and purpose of the notebook as well as understandings of the science content. A cross case analysis was conducted within these same categories. Overall, my findings support the idea that ongoing professional development, in the form of a study group, supports teachers as they implement reform-based measures within their classrooms. The longer a teacher participates the greater this impact on the teacher's beliefs, practices, and student outcomes.

In the next chapter, I present a substantive theory developed out of the comparison of these cases, and address how my findings support and extend the current literature and offer implications for policy, practice and future research.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

In this study, I sought to answer the questions: (a) How are teachers' beliefs and practices, as they relate to the use of science notebooks and write-to-learn strategies, impacted by participation in a study group focused on science notebooks? and (b) How do these beliefs and practices influence student performance in terms of notebook development and understanding of scientific concepts? The analysis of this study helped develop conceptual and empirical understanding about the two questions, which will be discussed in the following sections. First, I discuss the findings in terms of the impact of the study group over time, beliefs about the science notebook as a learning tool, and insightful use of the science notebook. Then, I discuss the findings in terms of how insightful use of the science notebooks influenced students' composition of conclusions, understanding of the content, and understanding of the purpose of a science notebook. Finally, I discuss how these findings led to the development of a substantive theory on the development of insightful implementation of science notebooks, demonstrating how teachers can move from mechanical use to insightful use. In addition, I make connections between my findings and the current literature; consider the implications these findings may have on policy, practice, and future research; and finally reflect on the limitations of this study.

Discussion

In this section, I discuss the findings related to each of the research questions.

How are teachers' beliefs and practices, as they relate to the use of science notebooks and write-to learn strategies, impacted by participation in a study group focused on science notebooks?

Based on the results of this study, I came to three understandings for this question. First, the longer an individual participated in this study, the greater the impact on her beliefs and practices appeared to be. Second, the study group may have influenced the teachers' beliefs towards science notebooks as a tool. Finally, the study group may have influenced the teachers' practices with science notebooks, leading to more insightful use. Each of these will be examined in more detail.

The impact of the study group over time.

The study group had impacted the way each of these teachers thought about science notebooks and the way in which they implemented them in their classrooms (Wildman et al., 2000). There appears to be a relationship between the amount of time they were involved in the study group and the type of impact it had upon their thinking, yet all of them gained additional instructional strategies, implemented new instructional practices, and saw some kind of gains in their students' understandings (Wei et al., 2009).

Although each of the teachers had different outcomes as a result of participating in the study group, they were engaged intellectually (Grossman et al., 2000) and took away new understandings of science notebooks. During Annie's first year in the study group, she gained concrete practices she could implement immediately in her classroom. Out of the three, Annie had the least developed ideas about science notebooks and tended to focus on the more mechanical aspects of the science notebook, such as recording observations. Throughout the study, Annie expressed concerns with her knowledge of the

content and her students' struggles to record their ideas in writing. Such concerns may have stretched her thinking too far and may have impeded the change process causing her to focus more on completing the task than incorporating the new ideas she was learning (Pintrich et al., 1993). Elizabeth had developed a sense that the science notebooks should be used to develop students' understandings. It was evident that the study group was pushing Elizabeth to question her current thinking and that she was pushing others within the group to think about their own beliefs and practices. Megan who participated in the study group the longest, seemed to have the most well developed ideas about science notebooks as learning tools. She took an active role, questioning her own practices and posing these questions to the group to invite others into her thinking.

Based on the findings of this study, a professional, collaborative study group can have an impact on a teacher's beliefs and practices. Teachers have a great depth of knowledge and should have a role in their professional learning (Cochran-Smith & Lytle, 1999; Darling-Hammond & McLaughlin, 1995). Study groups offer them the opportunity to pursue important ideas in a collaborative manner that invites them to share their knowledge and questions with others in the pursuit of intellectual growth. However, those in charge, implement workshop based professional development instead, perhaps not valuing the study group as a professional development model (Darling-Hammond & McLaughlin, 1995; Ladson-Billings, 1999). Appleton (2007) and Pearson et al. (2010) call for this thinking to change at all levels of education if educators are expected to fully understand and implement the reforms needed to teach in a standards-based manner.

While it is known that practice is typically impacted after 80-100 hours of traditional workshops (Levitt, 2002; Supovitz & Turner, 2000) and culture after 160 hours, it is

unclear how many hours are needed within a collaborative study group before such impacts are noted. Perhaps such impacts could be felt more quickly through a study group due to the personal involvement of the collaborative group. Based on the data of one meeting per month (assuming a nine month school year), at one and one half hours, for four years, Megan would have 54 hours of professional development through the study group, much less than the traditional workshop model yet it seems as though it has impacted her beliefs, practice, and student outcomes. Study groups have great potential to empower teachers and allow them to do the intellectual work needed to move students forward, however, more data is needed to help decision makers understand the power behind professional development and view it and fund it as legitimate professional development.

Beliefs about the science notebook as a learning tool.

Ruiz-Primo et al. (2004) found that "science notebooks can assist students' thinking, reasoning, and problem solving if used appropriately" (p. 1501). One way in which they are used appropriately is if the student and the teacher view them as tools to help facilitate student learning. In order for notebooks to serve as tools in this way, the teacher must believe that they are essential to student learning. Megan and Elizabeth saw the notebooks as tools. Megan's ideas about notebooks as tools were entrenched beliefs (Keys, 2005). They were enacted within her classroom as she explicitly stated to students that they were tools to help them learn.

Although Elizabeth talked about the notebook as a tool within her interviews, she did not refer to it as such during her lessons, nor did she ask students to use them as tools to support their thinking. Her actions portray expressed beliefs, as she was able to repeat

back beliefs she was hearing but did not yet implement them within her classroom (Keys, 2005). However, Elizabeth had made some changes, implying that while some beliefs were expressed others were more entrenched and she was acting upon them in her classroom.

Annie demonstrated a conflict between her current beliefs and the ideas she was learning in the study group. She mentioned that notebooks were tools, so she had some idea that they should be used as such; however, the majority of her comments focused on the science notebook as a means of recording observations and wonderings. It was this latter focus that was evident within her lessons. This implies that she was taking information about the science notebook as a tool from the study group, but had not fully grasped this idea yet and had not put it into her practice (Keys, 2005).

If science notebooks are to have the desired impact on student learning, it is important that the teacher views them as tools and clearly articulates this to her students, as Megan did. Therefore, the teacher must have strong beliefs that science notebooks help students learn the science, rather than simply serving as a place to document or record their information. Throughout her six years of using notebooks and four years of participation in the study group, Megan's views of notebooks changed due to a variety of factors (Pintrich et al., 1993), which may have included her own beliefs, classroom influences, and the social aspect of the study group.

Annie tended to focus on the mechanical aspects of the notebook, and at the time of this study, was more focused on the procedural aspects of the notebook than the student-centered aspects. Factors that bring about conceptual change include "personal, motivational, social, and historical factors" (Pintrich et al., 1993). These factors most

likely had some influence on Annie's experience during her first year in the study group. While Annie joined the study group out of dissatisfaction with the way in which she had been using science notebooks, and therefore was ready for change (Posner et al., 1993), there were factors involved that made this change more difficult, including: (a) Annie did not seem to have a personal belief that science and writing in science were important components of education, (b) she perceived challenges with in her classroom, and (c) she felt unsure of how to provide the guidance she felt her students needed.

Based on the findings of this study, it appears as though participation in a study group has the potential to impact an individual's beliefs about the topic being studied. This finding supports the research of Akerson et al. (2009) and Diezmann and Watters (2003) who found that collegial support had an impact on teachers' beliefs. In addition, it adds to the knowledge of research on collaborative study groups (Wei et al., 2009; Wildman et al., 2000), which refer to an impact on practices, but not beliefs. What is still unclear at this point is how much time it takes before such an impact is realized. After four years of participation, Megan credits the study group with her current ideas and has strong ideals about what the science notebook should look like and how it should be used. While Megan has developed entrenched beliefs, Elizabeth and Annie, with fewer years of participation, are not there yet. These changes in beliefs may be a result of time or they may be a factor of the individual's personalities. This is unclear and while this study supports study groups as a means of bringing about change in an individual's beliefs this area still has room for further exploration.

Insightful use of the science notebook.

Science notebooks have the potential of being powerful tools to help students use writing as a means to learn the scientific content (Baker et al., 2008; Keys, 1999; Pearson et al., 2010; Rivard, 1994; Rivard & Straw, 2000) however, to recognize this potential, science notebooks must be implemented in an insightful manner rather than in a mechanical manner (Yore et al., 2003). In order to use science notebooks insightfully, teachers must provide students with structured experiences that offer them supports or scaffolding to develop their recording strategies and/or scientific content (Appleton, 2007; Baker et al., 2008; Yore et al., 2003). Supports are strategies the teacher puts in place to support the students in focusing on the scientific content or the process of recording rather than the activity. Supports help students begin to understand how to use the science notebook as a learning tool, and they are always there and always available to the students.

In addition to supports the teacher should also put in place scaffolding that helps students take responsibility for what and how to record within their science notebooks (Appleton, 2007; Brophy & Good, 1986; Vygotsky, 1978). As students become more responsible, or aware, the scaffolding should be removed in order to prevent the students from becoming dependent upon it. If not removed, such scaffolds can become "straightjackets" (Warwick et al., 2003) in which students become either so rigid in their thinking that they are not able to move beyond the scaffold or so limited by it that they do not produce work that demonstrates their true capability.

In looking at the classroom practices of the teachers involved in this study, Annie, implemented notebooks in a more mechanical manner, which may have caused some of

her students to become dependent upon her notebook instruction. While she did not provide scaffolding, her students alluded to this idea of a straightjacket in their interviews. Annie was utilizing science notebooks in a very teacher-centered manner, providing structured experiences for her students, perhaps so structured that it limited her students' confidence with the notebooks and knowing what to put in them and how to use them. Rather than developing independence related to the notebook, her students were relying on her to guide their entries.

Elizabeth demonstrated some progression towards insightful use of the notebooks. She utilized some of the same types of supports as Annie, but in addition, she incorporated strategies that pushed students to think about the science content, moving towards using the notebook as a learning tool. Although Elizabeth's students did not allude to this straightjacket effect, scaffolds were used most prevalently in her classroom. However, Elizabeth questioned the degree to which she should provide such "supports" to her students, suggesting that while she thought these were helpful she was beginning to see how they might be limiting to the students as well.

Megan was the furthest along the progression towards insightful use. Her students' notebooks had similar information within them, yet each notebook was as unique as each student. She guided her students towards independent use of the notebook through the use of supports rather than a high level of scaffolding. Based on the notebook entries, Megan seemed to have provided her students with scaffolding earlier in the year, but had pulled most of it away by the time of this study; however, she still provided her students with many supports in using the science notebook as a learning tool. After four years in the study group, her implementation had become much more insightful. While this may

not be attributed to the study group alone, it may suggest that participation over time can have a positive impact on a teacher's practice in regards to science notebook implementation.

The findings of this study suggest that participation in a study group can have an impact on a teacher's practices related to the implementation of science notebooks. More importantly, this study uncovered some practices that help move the implementation of science notebooks away from mechanical use and towards insightful use, something that was not well articulated previously. This is an important contribution, in that it is difficult to implement a reform-based practice if it is unclear what this practice should look like. Previously, teachers had access to information on what notebooks should look like (Campbell & Fulton, 2003; Mintz & Calhoun, 2004) but these materials did not address strategies teachers could use to help create student-centered notebook entries focused on the content, so teachers reverted to what they knew from their own experiences (Lortie, 1975). The progression of notebooks, developed as part of this study and discussed later, displays how these three teachers were moving from mechanical use to insightful use through their instruction and the use of supports and scaffolds. While Megan was closer to insightful use of the notebook, it was evident that Elizabeth and Annie were moving in that direction as well and that perhaps more time in the study group might help them move further along this progression.

How do these beliefs and practices influence student performance in terms of notebook development and understanding of scientific content?

Based on the results of this study, I came to three understandings about student performance. First, when a teacher implements a science notebook in an insightful

manner, students' incorporate the components of a conclusion within their entries. Second, insightful implementation leads to greater student understanding of the content. Third, students' understanding of the purpose of a notebook is positively influenced by insightful implementation.

Components of a conclusion.

The use of conclusions has been found to increase student understanding (Ruiz-Primo et al., 2010); therefore, it is essential that students understand and incorporate conclusions within their science notebook entries. Megan's students utilized the components of a conclusion at a greater rate than students in Elizabeth's and Annie's classrooms. In addition, it was evident that Megan's students used these components over the course of the year, implying that they had been working on this important aspect for an extended period of time. Megan's strong beliefs about notebooks and insightful implementation led her students to use the components of a conclusion on a more regular basis, helping them develop their scientific understandings. Annie's implementation was much more mechanical in nature and her students' notebooks over the course of the year had a very low percentage of entries that contained the components of a conclusion. Elizabeth's focus on the use of "because" throughout the year may have led her students to incorporate the components of a conclusion throughout the year leading towards an understanding of the importance of writing in this manner even though her students did not utilize these components to a great extent during the duration of this study.

Understanding of the content.

Megan implemented notebooks in a more insightful manner, which resulted in her students demonstrating an understanding of the content within their notebooks and on the

posttest. On the opposite end of the spectrum, Annie implemented her notebooks in a more mechanical manner, which resulted in limited student outcomes in terms of their understanding of the science content. Elizabeth's implementation of science notebooks was progressing towards insightful use, although it was not yet there and her students struggled to clearly articulate the scientific content they were learning in the interviews and on the posttests. Elizabeth is progressing towards insightful use of science notebooks, and while she is not there yet, she is making progress. This progress is evident in her students' outcomes, and although they were not as positive as Megan's outcomes, they were stronger than Annie's outcomes.

Purpose of a science notebook.

An equally important component of science instruction is an understanding of the processes of science. Understanding the purpose and use of a science notebook would fit in this category. Megan's students were the only ones who were able to articulate the idea that a science notebook is a tool to help them and others understand science. The students in Annie's and Elizabeth's classrooms were more focused on how the notebook could help them remember something. The concept of the notebook as a tool was a staple of the science notebook study group discussions over the years, perhaps influencing Megan's beliefs and explicit instructions on using the science notebook as a tool for learning.

The results of this study suggest that a teacher's involvement in a study group can have an impact on her beliefs and practices, which in turn can impact her students' performance in terms of scientific understandings. While there are other factors, such as content knowledge (Brophy, 1986; Hill, et al., 2005; Ma, 1999; Shulman, 1986) that have

to be taken into consideration, one cannot discredit the way in which Megan utilized the science notebook, as a write-to-learn tool, as a possible factor to her students' successful outcomes. Megan gained her beliefs and instructional strategies, at least in part, through her on-going participation in the study group. The findings here support the work of others. First, Wei et al. (2009) also found that professional collaborative groups led to academic gains for students. Second, it supports the findings of Lee et al. (2009) in that Megan received more "treatment" than the other participants and had higher student outcomes as a result. Third, it supports Choi et al. (2010) in that primary aged students were able to compose conclusions. Finally, it supports the work of Ruiz-Primo et al. (2010) in that Megan had the highest percentage of parts of a conclusion within her students' notebooks, which Ruiz-Primo found led to higher student achievement as well. Again, this raises the question of how much time must one invest in collaborative study groups before positive student outcomes are produced, since student outcomes were not as positive for Elizabeth and Annie.

Substantive Theory: Development of Insightful Implementation of Science Notebooks

Growing out of the above findings is a substantive theory on the Development of Insightful Implementation of Science Notebooks. This theory suggests that implementation of science notebooks moves from mechanical to insightful use through a progression of instructional shifts the teacher makes to move from a more teacher-centered to a more student-centered implementation of the science notebook. This progression is accomplished through the use of various teaching strategies, including the

use of supports and scaffolds. This theory clearly infuses the important ideas of conceptual change and the sociocultural learning perspectives.

The first component of this theory is connected to Vygotsky (1978), who surmises that learning moves from social to individual understanding over time as an individual negotiates meaning based on their interactions with others. In this sense, learning and development take place at the same time, building off of one another, rather than development occurring in distinct stages. In this study, the teachers were involved in an on-going process of learning how to implement science notebooks through their interactions with others, including study group members and their students, which impacted their developing beliefs about science notebooks. This can be represented as a progression in which the teacher's moves have an impact on notebook use and student outcomes. Within the zone of proximal development, Vygotsky theorized how functions range from budding to mature. Based on these ideas and the work of Putney and Broughton (2010), I developed a sliding scale that demonstrates the relationship between a teacher's implementation of the science notebook with Vygotsky's zone of proximal development (Figure 33).

Development of Science Notebook Implementation	Science Notebook Implementation Onset	Science Notebook Implementation Developing	Science Notebook Implementation Maturing
in relation to			
Vygotsky's Zone of Proximal Development	Actual Development	Proximal Development	Potential Development
	← Ongoing Participation in Professional Development →		

Figure 33. Science Notebook Implementation Development Scale.

As Vygotsky (1978, 1986) theorized, the teacher's understanding and implementation of science notebooks can be developed through the context of the professional development and the interactions with the more experienced members of the study group. Based on the findings of this study Figure 34 illustrates development of science notebook implementation from onset to maturing. If the onset of science notebook implementation could be considered mechanical use, then the maturing of science notebook use could be considered insightful use.

Implementation of Science Notebooks	**Onset**		**Developing**		**Maturing**
Focus	The notebook as "bound work-sheets"	The notebook as a recording device	The notebook as a resource	The notebook as a tool	The notebook as a learning tool
Actions	Teacher either dictates what to record or leaves all decisions open to the students. Focuses on the science activity and basic elements.	Teacher reminds or suggests that students use particular strategies to record. Focuses on the basic elements and observations.	Teacher guides development of the notebook through supports and scaffolding. Focuses on the scientific content.	Teacher continues to guide development and provides opportunities for students to self-assess their entries. Focuses on student understanding of the scientific content.	Teacher structures opportunities/ experiences to help students determine meaningful ways to collect and organize data and to synthesize their work. Focuses on students using information in the notebook to push their understanding of the scientific content further.

Figure 34. Development of Science Notebook Implementation from Onset to Maturing.

The second component of this theory connects to the conceptual change model which surmises that prior understandings serve as the means for making sense of new concepts (Gertzog, 1982). Current conceptions change when individuals become dissatisfied with their present thinking and come into contact with new information that is considered to be plausible and fruitful. In this study, all of the teachers were dissatisfied with their current understanding of science notebooks and sought out professional development, in the form of the study group, to help them grow in this area. The process of change is not abrupt, but rather gradual, in which an individual accommodates some aspects of a new concept while assimilating other ideas. This gradual process eventually leads towards the modification of other ideas and an overall change in a person's conceptual thinking (Posner et al., 1982). These changes can be represented as a progression from mechanical use of science notebooks to insightful use, through subtle shifts in instruction and the use of strategies, such as supports and scaffolds.

This idea of a gradual change in thinking along with the progression in Figure 34 formed the basis for a substantive theory, Development of Insightful Implementation of Science Notebooks, which describes how teachers progress from mechanical use to insightful use of the notebook. I will present the basis of this theory within the body of the text, starting with Figure 35, which presents the overall theory. Then I will develop each of the three components, (a) instruction, (b) supports, and (c) scaffolds to build on the theory. Full size versions of the s can be found in Appendix L.

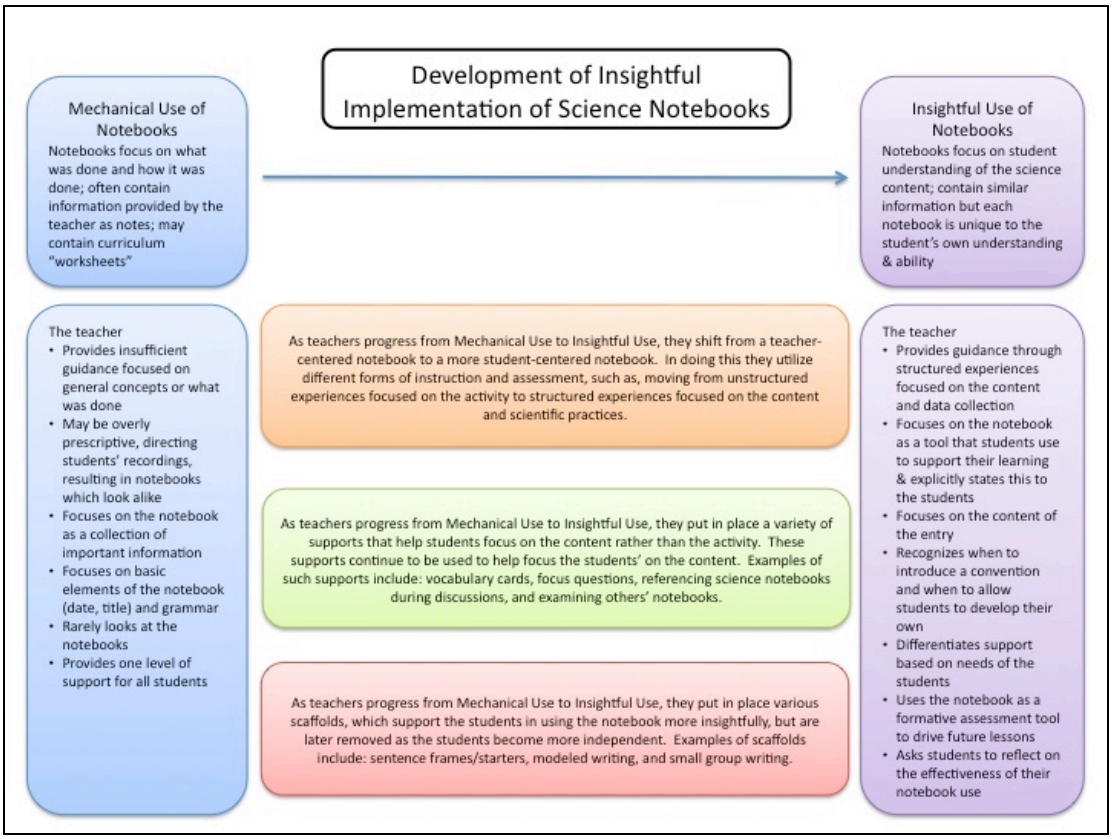

Figure 35. Development of Insightful Implementation of Science Notebooks.

When teachers are first introduced to science notebooks, their focus is often mechanical in nature, focusing more on helping students make the notebooks look good and get the important information recorded within it. This is similar to the way in which Megan described her implementation of science notebooks at the beginning of her career. As teachers learn more about notebooks and how to use them, they progress from this mechanical implementation, which is usually quite teacher-centered, similar to the way in which Annie implemented her notebooks, to a more insightful implementation, which is usually more student-centered, such as the way in which Megan utilized notebooks within this study. Along this progression shifts in the teachers' instruction take place (Figure 36) and they utilize a variety of strategies, including supports (Figure 37) and scaffolds (Figure 38).

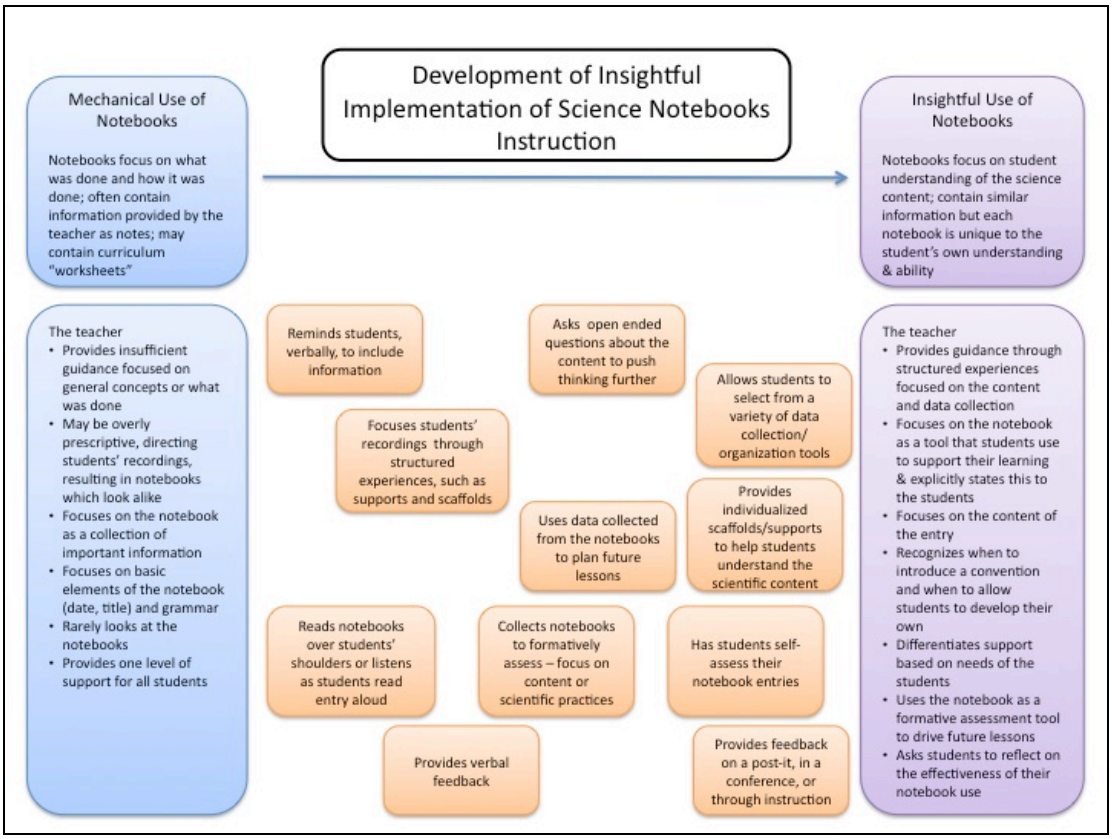

Figure 36. Development of Insightful Implementation of Science Notebooks – Instruction.

This gradual change has taken place over four years for Megan, as she took ideas introduced in the science notebook study group and made them her own (Vygotsky, 1978). Elizabeth, who has participated in the science notebook study group for two years, appears to be experiencing this gradual change, related to her beliefs about science notebooks, as well, although it was not as evident in her practice as it was in Megan's. The goals and timing of the task are essential in helping bring about this change (Pintrich et al., 1993), which may have made this change easier for Megan, than for Elizabeth or Annie. Furthermore it is essential that the tasks engage the learner without stretching them too far (Pintrich et al., 1993), although Lave & Wenger (1991) discuss the importance of creating a learning environment that is

complex and robust. Annie encountered many struggles, suggesting that she may have been stretched too far, which may have limited her learning (Duit & Treagust, 2003). However, the social aspect of the study group may have helped Annie to some extent, as she was able to identify with the struggles that others were experiencing, learn from others' ideas, and hear of successes that others were experiencing (Lave & Wenger, 1991; Lemke, 2001; Pintrich et al., 1993).

Within instruction, there are simple steps the teacher may make to begin moving away from mechanical use; Elizabeth was at this stage of development. She was structuring experiences for her students to help focus their recordings on the scientific content rather than the activity and she was contemplating whether to use them as a formative assessment tool for herself. She also shared how she was having her students engage in self-assessment of their notebook entries. Megan had moved further along this progression towards insightful use and was doing such things as providing feedback to her students and using the data she collected to drive her future lessons. Probably one of the more common instructional steps a teacher might take is to structure the science notebook experience using various supports or scaffolds to help students focus their recordings.

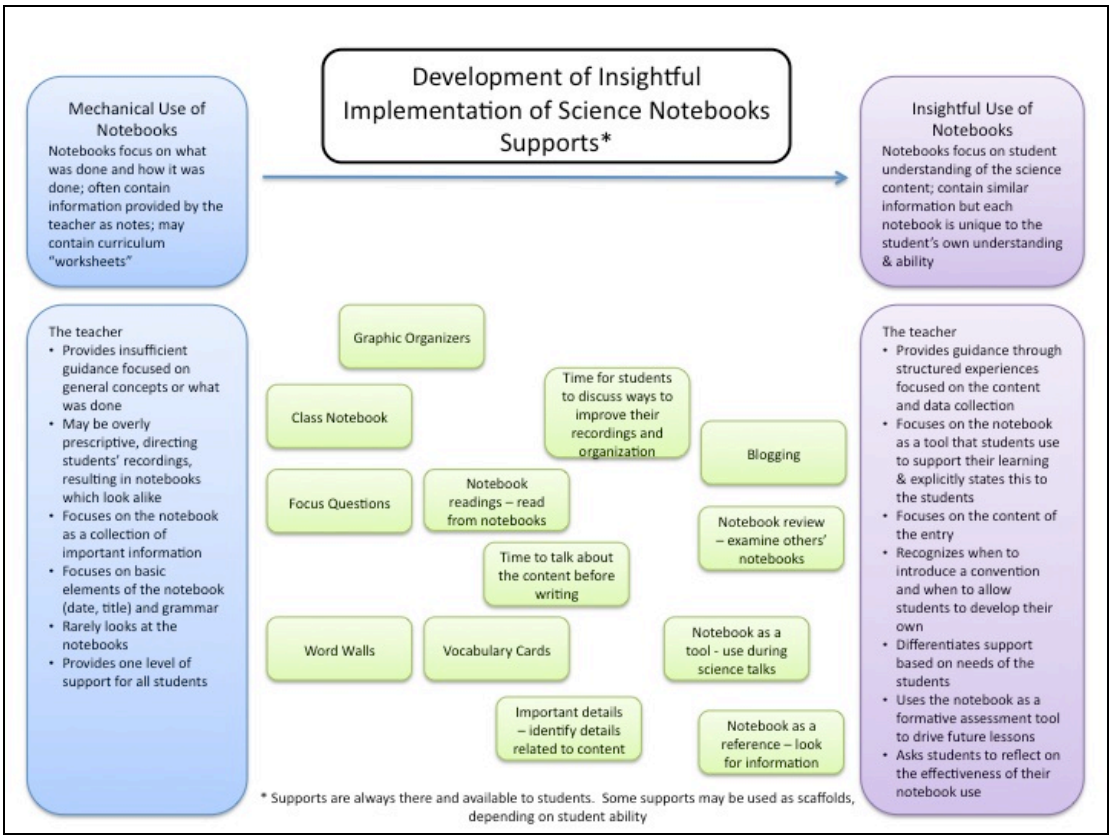

Figure 37. Development of Insightful Implementation of Science Notebooks – Supports.

Supports are strategies the teacher puts in place that are always there and always present for the students, such as focus questions and word walls. Again, there are some simple supports the teacher may feel comfortable putting in place right away or may be part of a curriculum, such as a word wall. Many of these types of supports were present in Annie's instruction. Other supports may take more time to implement, such as having the students use the notebook as a tool during a science talk, which was evident in Megan's room. Since supports are always present, once a teacher introduces a simple support such as focus questions and vocabulary cards, it would be expected that these continue to be implemented as long as they help the students access the content. This was evident in both Megan's and Elizabeth's classrooms. It is important to note that some supports may look different depending on the ability of the students, and those

displayed within the theory correlate to the second grade students, from which data was collected in this study. The important idea is the supports provide students with a means to access the knowledge (Vygotsky, 1978, 1986).

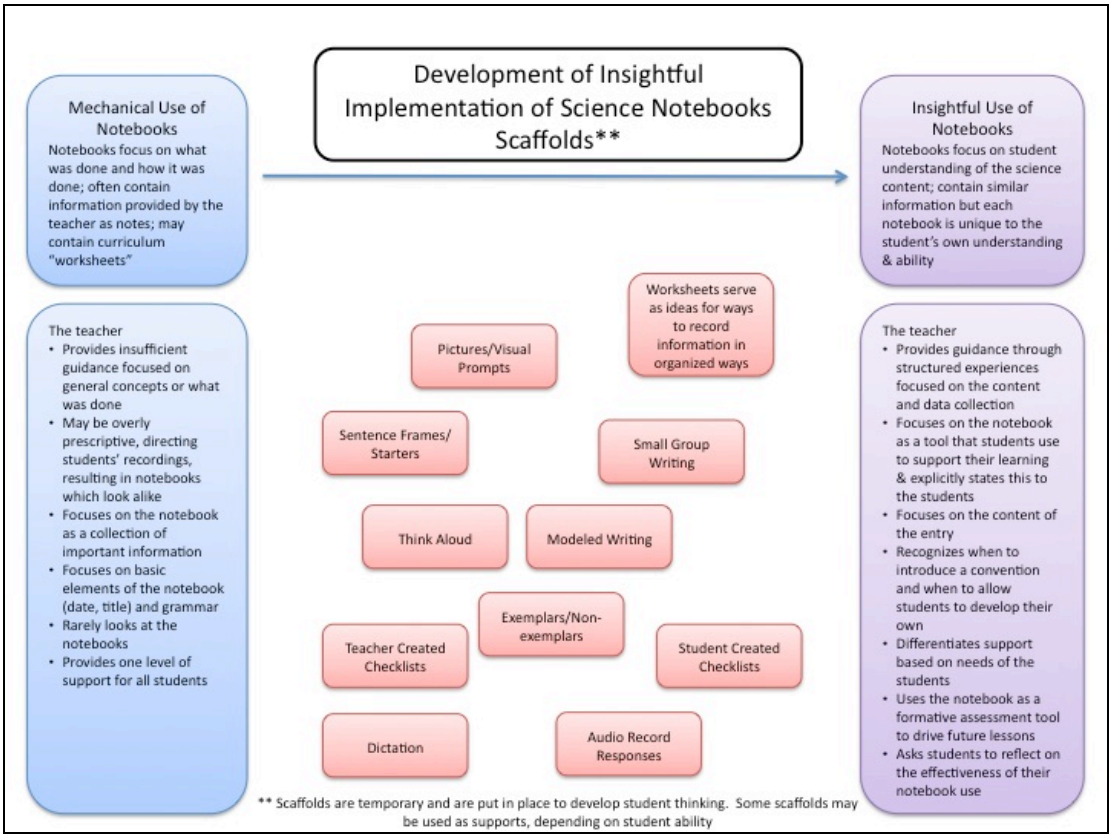

Figure 38. Development of Insightful Implementation of Science Notebooks – Scaffolds.

Scaffolds are strategies the teacher puts in place that help develop student thinking; however, scaffolds change over time in order to move the students' thinking forward and are removed altogether at some point to continue to prevent students from becoming reliant upon them (Warwick et al., 2003) and push their own thinking further. Pressley (as cited in Honing, Diamond, & Gutlohn, 2008, p. 625) provides a scaffolding metaphor

> The scaffolding of a building under construction provides support when the new building cannot stand on its own. As the new structure is completed and becomes freestanding, the scaffolding is removed. So it is with scaffolded adult-child academic interactions. The adult carefully monitors when enough instructional input has been provided to permit the

> child to make progress toward an academic goal, and thus the adult provides support only when the child needs it.

Again, some scaffolds might be easier for teachers to put in place right away, such as sentence frames/starters, and others might take longer to develop, such as using student created checklists that allow students to assess an entry themselves. Scaffolds were not present in Annie's lessons; even though she provided her students with a sentence starter at one point, it was only provided verbally, making it difficult for students to use it in a meaningful manner. Elizabeth implemented many scaffolds, but it did not appear as though these were changing over the course of the year. As stated earlier, a problem can occur with scaffolds, in that teachers can leave them in place for too long, causing the students to become dependent upon them. Elizabeth struggled with this idea and although she referred to it as "support" she wondered how much structure was too much for her students and if it would develop dependency amongst her students. During the lessons Megan taught for this study, she utilized one support, having her students audio record their responses, but it was evident through the notebooks that she had used other scaffolds earlier in the year, such as sentence starters and visual prompts.

The sociocultural perspective describes learning as being tied to the web of practices of the community in which it is situated (Lave & Wenger, 1991; Lemke, 2001). Megan created a community in which she made explicitly clear the purpose of a science notebook, provided opportunities for students to use the notebook as a tool, structured experiences in a way that promoted student independence, and expected students to record in a manner that promoted their scientific understandings. She made the knowledge available for her students on the social plane (Vygotsky, 1978), which allowed them to make sense of it and performance

was impacted as a result. Neither Elizabeth nor Annie created this type of community. Instead they held onto the knowledge rather than releasing it to the students and structuring experiences in a way that encouraged reliance upon the teacher, which ultimately prevented most students from being able to make sense of the purpose of a notebook as well as the scientific content (Vygotsky, 1978).

This substantive theory provides educators with a vision of what both mechanical and insightful use look like and provides them with steps they can take to move themselves beyond the onset of science notebook implementation to the maturing function of science notebook implementation. This progression was previously unclear, which may have prevented some from realizing that there was more to science notebooks than previous sources had implied.

Implications

Although these findings cannot be generalized to a larger population, there are implications that may be applicable to policy, practice, and future research. These implications are considered in this section.

Policy

Teachers have a wealth of knowledge about the subjects they teach and should be encouraged to drive their own professional development through collaborative study groups. However, professional development is usually viewed as a workshop in which somebody from outside of the school provides information to the teachers. This is an old view of professional development that needs to change if the goals of standards-based education are to be realized (Appleton, 2007; Pearson et al., 2010). Teachers need to be empowered as experts within their profession and demonstrate to others that when

provided with the opportunity they can facilitate their own learning in a way that impacts their beliefs, practices, and student outcomes. This cannot be done alone though, so time and resources need to be provided for teachers to engage in this type of professional development within the school day, such as they do in Japan and China (Stigler & Heibert, 1999; Wang, 2001), and it must be viewed by the teachers, administrators, and policy makers as a valuable use of their time.

In this study, I served as what Fernandez (2005) refers to as a "teacher of teachers," serving as a knowledgeable individual within the group. In this role, I was able to gather resources to help guide the discussions and push thinking further. However, at times other teachers stepped in to this role. This role of a teacher of teachers might be an important one to consider in putting professional study groups together in order to determine if it is a necessary component, if a classroom teacher can fill this role, or if it needs to be an individual with expertise in facilitation, mentoring, and/or content. If it is found that expertise is needed, then it must be determined what type of expertise is required and what type of professional development a person needs to take on this role. I believe this is important to consider, as I was not an outsider in this role, but rather a member of the school and group on a journey with the others to learn as much as I could about science notebook implementation. This helped to build trust within the group and allowed others to take on this role as they felt the need to do so.

Such a shift in professional development must be studied further so that all stakeholders understand the components that make this type of professional development successful and the impact it may have on educators and students.

Practice

In terms of practice there are implications for the elementary classroom as well as teacher education programs.

Elementary classrooms.

Many teachers use science notebooks as a means to integrate writing and science; however, they are unclear about how to use them in the most productive way to advance student learning. The current work (Aschbacher & Alonzo, 2006; Baxter et al., 2001; Campbell & Fulton, 2003; Gilbert & Kotelman, 2005; Shepardson & Britsch, 2001; Worth et al., 2009) describes the elements of a science notebook and the type of writing that may be included in a notebook, but it does not provide a clear picture of how to use the science notebook as a tool to promote student learning of the scientific concepts. The theory this study puts forth, the Development of Insightful Implementation of Science Notebooks, fills this gap and can be used by classroom teachers to guide their instruction and discussions with colleagues.

Furthermore, this study confirms that science notebooks can serve as powerful learning tools for students; however, teachers must believe that they serve as tools to help students learn about the scientific content rather than simply record what was done in science that day. Not only do teachers need to understand how notebooks can serve as a learning tool, but they need to provide students with the assistance they need in learning how to use the notebook as a tool, including what types of information they should record, how they might record it, and how to use that information after recording it. Teachers need to put supports and scaffolds in place to help students with these aspects of the notebook. The progression of science notebooks can help teachers determine

appropriate strategies to implement in order to help students in this way. When notebooks are used in this manner, they have the potential to increase student understanding of the purpose of a science notebook as well as understanding of the scientific content, as demonstrated by the students in Megan's classroom.

Teacher education.

Teacher education programs serve as the basis for most teachers in the profession, therefore, it is essential that best practices be modeled and discussed at this early stage. While much of the teaching profession is isolated to a single classroom, students should be learning the power that exists in collaborating with others, and the idea of collaboration should be entrenched by the time they graduate. They should view themselves as professionals with expertise about their content and students; expertise that they should be willing to share with others in order for all parties to grow. Classes should build in opportunities for students to engage in collaborative discussions around planning, strategies, student work, and other important issues. Ideally, these collaborative groups would take place within a school setting, where pre-service and in-service teachers could come together and discuss real issues taking place within a building pertinent to the course content. Although the students will not have all the answers and need a knowledgeable other, such as a professor, there to guide them it is essential that the image of professional learning change at this early stage to have any sort of lasting and wide impact. Teachers need to stop seeing others standing before them, as the holders of knowledge, and instead begin to see themselves as knowledgeable professionals who are empowered to and capable of driving their own professional growth.

The *National Science Education Standards* (NRC, 1996), the *Benchmarks for Science Literacy* (AAAS, 1993) and *A Framework for K-12 Science Education* (NRC, 2011) all point to the importance of having students write and document their work within science, so it is essential that science content courses and methods courses for pre-service teachers incorporate insightful use of notebooks within their curriculum. Since modeling best practices is of importance, science methods classes should look at the way in which they are utilizing science notebooks. They need to determine if they are placing an emphasis on the mechanical use of notebooks and perpetuating this focus of recording what we did in science today or are they focusing on the elements of insightful use and modeling the use of supports and scaffolds to help improve entries. Since individuals learn through observation (Lortie, 1975) it is essential that notebooks be used in the manner in which we expect teachers to implement them in their own classrooms. Furthermore, it is essential that students be engaged in the practices we want them to partake in as professionals, including reflecting on notebook entries and collaborating with their peers. Students should be engaged in looking at common science notebook entries and discussing the focus of the entry and next steps to move the child forward. Such steps will help ensure that students enter the profession with strong practices in place.

Future Research

First, in order to bring about policy changes to the way professional development is delivered, further research is needed to better understand how study groups serve as a means of teacher-driven professional development and to reassure all stakeholders that study groups can deliver the results they are looking for. Some opportunities for future research have been mentioned above, such as examining the length of time one must be

involved in a study group before it has an impact on their beliefs and practices and what components are essential to ensure that collaborative study groups have a positive impact as a professional development model. Past research has examined the impact study groups have on teachers' practices (Wei et al., 2009; Wildman et al., 2000), understanding of the content (Grossman et al., 2000), and student academic outcomes (Wei et al., 2009); however, the impact on a teacher's beliefs is lacking. This study contributed to this area, however, more research is needed to determine if other study groups can have an impact on teachers' beliefs.

Second, this study proposed that one can trace a teacher's progression of implementation of science notebooks from mechanical to insightful use, and presented a theory of what this might look like with specific strategies that teachers could use to move towards insightful use. Following the work of Vygotsky (1978), Appleton (2007) and Pressley (as cited in Honing et al., 2008), the progression suggests that there are two types of strategies, supports and scaffolds, of which the latter should be temporary in order to help students get to the content, whether that be physical science or the nature of science and learning how to record and organize information within the notebook. While I believe this progression will help teachers realize what science notebooks can be, and how to develop their instruction in order to help students recognize science notebooks as learning tools, this has yet to be tested with teachers. I would encourage others to share this with teachers and follow their progress as they move from mechanical to insightful use in order to see if they follow a similar progression, if there are spots at which they get stuck, and how long it may take an individual to make this progression.

Within this study, Elizabeth questioned how much "support" she should provide her students either through the use of supports or scaffolds. Warwick et al. (2003) found that the scaffold of a sentence frame could become a straightjacket, is the same true for scaffolds presented within this development? Finally, past research (Ruiz-Primo et al., 2010) demonstrated that science notebooks have the potential to improve student achievement when used correctly, but their research was not connected to professional development. This study connected students' notebook entries, student performance, and professional development, but more is needed in order to establish a pattern and to determine if Megan's outcomes were a result of her involvement in the study group, her knowledge of the content, or some other variable.

Limitations of the Study

As with any research, this study has limitations. As a case study, it has built in limitations in that the findings apply to the individuals within this study and cannot be generalized to a broader context. In addition, the short duration of this case study, within a six-month time frame, when the study group has been ongoing for four years, provides a limited snapshot of these cases and the impact the study group may have had upon them. Due to the short time span of this study and the ongoing nature of the study group, changes in teachers' beliefs and practices were inferred based on their answers to questions asked in the interviews; therefore, it is difficult to know how much change actually took place since the individuals first started participating in the study group and how much of this change can be attributed to the study group setting. Furthermore, while care was taken in establishing a purposeful sampling, there are several variables that cannot be controlled and may factor into the differences found between the teachers.

Finally, my personal involvement with the individuals may be seen as a limitation or benefit. Some may say it is a limitation as it brings with it biases that may be difficult for me to see beyond. However, others may see it as a benefit in that I had an established rapport with the teachers and had insider knowledge of the context.

Conclusion

Using a qualitative multi-case study, this research suggests that a teacher's beliefs, practices, and student outcomes can be impacted through participation in a professional study group. Furthermore, it suggests that the longer an individual participates in the group, the greater impact it has on the above aspects. Based on the data collected, a theory on the Development of Insightful Implementation of Science Notebooks was established to clearly define what notebook use looks like when implemented in a mechanical versus insightful manner and the types of strategies that can help notebooks become more insightful, leading to higher student performance. The teachers within this study were at different points along this progression, with the one closest to insightful use seeing a greater impact on student performance. Based on these findings, it is suggested that this progression may help teachers incorporate science notebooks as learning tools. Finally, it is suggested that study groups can have an impact on teachers' beliefs, practices, and student outcomes and should be studied further to fully understand the degree of this impact.

APPENDIX A: METHODOLOGY TABLE

Question	Participants	Data Source	Analysis
1. How are teachers' beliefs and practices, as they relate to the use of science notebooks and write-to-learn strategies, impacted by participation in a study group on science notebooks?	• Megan • Elizabeth • Annie • Classrooms of Megan, Elizabeth, and Annie • Study Group	• Classroom Observations - Field Notes & Transcripts • Observation of Study Group – video / field notes • Interview Transcripts • Lesson Plans	• Event Mapping • Coding
2. How do these beliefs and practices influence student performance in terms of notebook development and understanding of scientific concepts?	• Students of Megan, Elizabeth, and Annie	• Student Notebooks • Assessment of Science Content • Interviews	• Content Analysis • Domain Analysis • Taxonomic Analysis • Coding

APPENDIX B: TIMELINE FOR DATA COLLECTION & ANALYSIS

Timeline	Data Collection Task	Analysis
January		
1/7/2011	Study Group Meeting Observation	Transcribe and Code; Event Map
1/7/2011	Survey of Teachers' Beliefs	Code
Schedule w/ teachers	Initial Interviews of Teachers (3)	Transcribe and Code
February		
2/4/2011	Study Group Meeting Observation	Transcribe and Code; Event Map
Schedule w/ teachers	Student Initial Interviews (3/class – 9 total)	Transcribe and Code
March		
3/4/2011	Study Group Meeting Observation	Transcribe and Code; Event Map
3/7-11/2011	Student Pretest – Science Content	Code
3/14-31/2011	Videotape Lessons from FOSS Solids and Liquids kit	Transcribe and Code; Event Map
3/31/2011	Study Group Meeting Observation	Transcribe and Code; Event Map
April		
4/1-29/2011	Videotape Lessons from FOSS Solids and Liquids kit	Transcribe and Code; Event Map
4/25-29/2011	Mid Interview of Teachers (3)	Transcribe and Code
May / June		
5/1-6/3/2011	Videotape Lessons from FOSS Solids and Liquids kit	Transcribe and Code; Event Map
5/6/2011	Study Group Meeting Observation	Transcribe and Code; Event Map
Schedule w/ teachers	Final Interviews of Teachers (3)	Transcribe and Code; Event Map
Schedule w/ teachers	Classroom Observation / Video – Teacher	Transcribe and Code; Event Map
5/31-6/3/2011	Student Final Interviews (3/class – 9 total)	Code
6/3/2011	Student Posttest – Science Content Collect Students' Science Notebooks	Content/Domain/Taxonomic Analysis

APPENDIX C: TEACHER INTERVIEW PROTOCOLS

Initial Interview Protocol – Science Notebooks

Teacher's Name: _____

Date: _____ Beginning Time: _____ Ending Time: _____

Place: _____

1. How do you think teachers develop their skills and knowledge? How do you think students develop their skills and knowledge?

2. How would you describe your role in your student's learning and why?

3. What are your current views of science, science learning, and teaching? Have your views changed over time? If so, what are the changes?

4. What do you see as the role of writing in the elementary science classroom? What do you see as the role of science notebooks in the elementary science classroom?

5. How did you acquire these ideas about writing and science notebooks?

6. What is the most challenging aspect of implementing writing in science and science notebooks with your students?

7. What type(s) of personal experiences have you had with using or learning about science notebooks? (for example, keep your own notebook, attended a workshop, talk with colleagues, etc.)

8. In what ways have your ideas about science notebooks been impacted by your personal experiences?

9. How might you help students learn to use a science notebook? How might you help them use it as a tool to develop their conceptual understandings in science? Why do you think you would structure it in this way?

10. If you had to articulate your goal for your student's use of the science notebook, what would it be?

11. What do you find to be most challenging for you in facilitating the use of notebooks?

12. What ideas have you learned in the study group and implemented within your classroom?

13. How do ideas shared within the study group align with or differ from your ideas of science notebooks?

14. Are there any other issues / concerns that you would like to discuss?

Mid-Interview Protocol – Science Notebooks

Teacher's Name: _____

Date: _____ Beginning Time: _____ Ending Time: _____

Place: _____

Background

1. How do you view the importance of science compared to other subject areas at the elementary level? Why?
2. How do you think the majority of your students learn science? How do you think they convey their understanding of what they are learning? What role does writing play in conveying their understandings?
3. Can you describe your preparation in teaching science during the major stages of your education? How did your science education contribute to your learning of the science content for this specific grade level and the unit you are currently teaching?

Unit Assessment

4. How is the unit coming along at this moment?
5. What are some of your major goals for your students to learn in this unit in terms of scientific content? In terms of scientific writing?
6. Please describe what concepts your students easily grasped and what concepts your students are struggling to learn in terms of the science content and in terms of the scientific writing. How do you know this?
7. Can you describe and explain any surprises that you have encountered during your teaching of the unit so far? Have you encountered any barriers or problems?

Influences

8. How have your students influenced the way you have taught or planned for this unit in terms of the scientific content and use of the science notebook?
9. Has anyone else influenced the way you have taught or planned for this unit in terms of the scientific content and use of the science notebook? If so, who has influenced you and how?
10. If you were able to teach this unit in an ideal situation, what would it look like?
11. Which aspects, if any, and to what extent have these ideas been impacted by your professional development experiences?
12. At any time during the teaching of this unit so far, have you thought about anything you have learned or experienced from the professional development sessions that you have attended? Why or why not?
13. Are there any issues of concerns you would like to discuss regarding your teaching, our interviews, or project?

Thank you for taking the time to answer these questions, I appreciate your participation in the project.

Final-Interview Protocol – Science Notebooks

Teacher's Name: _____

Date: _____ Beginning Time: _____ Ending Time: _____

Place: _____

Background

1. Please describe what effective or good science teaching looks like? What role does writing play in your idea of good science teaching?

Unit Assessment

2. Please compare your best and worst lesson in the solids and liquids unit. Why do you consider these lessons to be the best and worst? What was your role in these lessons?
3. What were some of your major goals for the unit in terms of scientific content? In terms of scientific writing or use of the science notebook? Did you meet these goals?
4. In this unit, what were some of the easiest and most challenging aspects of planning and teaching it? Please explain in detail. Please describe and explain any surprises that you have discovered while teaching this unit.
5. How do you view your students' learning in this unit? Did they grasp the scientific concepts easily or have some difficulties? Did they grasp the science writing ideas easily or have some difficulties? Why do you think it is important to teach those ideas?
6. What do you consider to be the most important concepts that your students learned during this unit? How do you know whether students learned these concepts or not?
7. What were your students' general attitudes towards science learning during this unit? Towards the use of writing in science or the science notebook during this unit?
8. What teaching strategies did you use during the unit to teach the science content and the scientific writing/science notebook? Did any of these strategies deviate from your original plan? How did you learn about these strategies?
9. If you were going to teach this unit again, what changes, if any, would you make?
10. What major barriers or problems, if any, did you face while teaching this unit?

Influences

11. What does writing in science mean to you? How would you describe a lesson that focuses on writing in science? Could you describe a lesson that you taught during this unit that focused on writing in science or use of the science notebook?
12. Are there any issues or concerns that you would like to discuss about our interviews and/or project?
13. How much influence did the videotaping have on your teaching? And if you were to re-teach this unit without videotaping, what changes to your teaching, planning, or materials would you make?

APPENDIX D: STUDENT INTERVIEW PROTOCOLS

Student Initial-Interview Protocol – Science Notebooks

Student's Name: _____

Teacher's Name: _____

Date: _____ Beginning Time: _____ Ending Time: _____

Place: _____

I want to talk with you today about what you are doing in science. There are no right or wrong answers, I just want you to share what you think. This will help me better understand how you are learning about solids and liquids and science notebooks.

1. Do you like science? If so, what is your favorite part of science? What is your least favorite part of science? If not, what do you not like about science?
2. Do you like writing? (creative stories, in your science notebook, in your life book)
3. What kinds of things do you put in your science notebook?
4. How do you use your science notebook?
5. Show student his/her entry on building a tower. Can you tell me about your entry? What do you know about building a tower? What solid is best to use at the base? Why? What is the most important part of this entry? Why?
6. Do you think your science notebook is important? Why or why not?

Student Final-Interview Protocol – Science Notebooks

Student's Name: _____

Teacher's Name: _____

Date: _____ Beginning Time: _____ Ending Time: _____

Place: _____

We talked before about what you are doing in science and your science notebook. I just wanted a chance to talk with you again about it. Just like before there are no right or wrong answers. I'm just curious what you're thinking. Okay

1. Last time you told me that you like science, what is it that you like about science? Is there anything about science that you don't like? If so, what is it?
2. How are solids and liquids the same? How are they different?
3. How do you know if something is a solid or a liquid?
4. Show students a page from bits and pieces where they recorded their thinking about cornmeal or rice. Can you tell me about this page? Did you put the date on this page? Why or why not? Did you put a title on this page? Why or why not? Did you include a picture on this page? Why or why not? Did you include words on this page? Why or why not? Did you include samples on this page? Why or why not?
5. What are some important things you put in your science notebook every time you do science?
6. How do you think a scientist uses their science notebook?
7. Does your teacher help you know how to use your science notebook or what you should put in your science notebook? How does she help you?
8. Do you have anything else you want to share or tell me about today?

APPENDIX E: SCIENCE NOTEBOOK RESEARCH QUESTIONNAIRE

This study investigates what elementary teachers think about teaching science using science notebooks. I am interested in your views about learning and teaching with science notebooks. Please answer all the questions. I need your responses to all of the questions in order to understand as much as possible about what you think.
The information collected will not be used in any way that would reflect on you personally. What you say will be held in confidence, and I will not use your real name in any reporting of data.

PART 1: Background Information

A. Personal information

Your Name:			
Today's Date:	Year	Month	Day
Your Birth Date:	Year	Month	Day

B. Education background

Questions	Answers
1. When did you graduate from high school?	
2. What type of teacher preparation did you participate in? (traditional, alternative route, etc.)	
3. Where did you receive your teacher preparation? List all if more than one education institution.	
4. When did you receive your teacher preparation? From which year to which year.	
5. What is the highest degree of education that you have earned?	
6. What was your major field of study? (undergraduate, graduate) List all if more than one field.	

C. Teaching and job information:

1. When did you start your teaching career? Write down the exact year and month.	

2. How long have you been teaching? From which year to which year.	
3. How long have you been teaching science with science notebooks? From which year to which year.	
4. How many schools have you taught in?	
5. When did you begin teaching at Jones ES?	
6. What grade levels have you taught? List all the grade levels if more than one	
7. What grade levels have you taught science using science notebooks? List all the grade levels if more than one	
8. What is the major reason that you decided to become a teacher?	
9. In addition to teaching, what other jobs did you have before? List all if more than one	
10. Which subject area do you enjoy teaching the most?	
11. When did you join the Science Notebook Study Group?	
12. What was your main reason for joining the Science Notebook Study Group?	

PART 2: Teaching and Learning of Science Using Science Notebooks

A. Degree choice items

For the statements below, indicate your agreement or disagreement by circling the number that best expresses what you think about the statement. Your replies to these statements can range from **strongly disagree as 1 to strongly agree as 7.**

```
      1       2       3       4       5       6      7
<-------o--------o--------o--------o--------o--------o--------o------->
```

1=Strongly disagree.
2=Less strongly disagree.
3=Disagree.
4=Neutral.

5=Agree.
6=Less strongly agree.
7=Strongly agree.

1. Science just isn't my strength and I avoid it whenever possible	1 2 3 4 5 6 7
2. I'm pretty good at science and I enjoy the challenge of it.	1 2 3 4 5 6 7
3. I can handle basic science, but I don't have the kind of mind needed for advanced science.	1 2 3 4 5 6 7
4. I feel OK about science. I'm neither strong at it nor fearful of it.	1 2 3 4 5 6 7
5. If I would give it full effort, I know I could learn advanced science.	1 2 3 4 5 6 7
6. Doing science allows room for original thinking and creativity.	1 2 3 4 5 6 7
7. Doing science is usually a matter of working logically in a step-by-step fashion.	1 2 3 4 5 6 7
8. Many things in science must be accepted as true and remembered with no explanations.	1 2 3 4 5 6 7
9. High school biology, physics, and chemistry are totally different from what students learn in the lower grades.	1 2 3 4 5 6 7
10. Science helps you learn to think better.	1 2 3 4 5 6 7
11. Science is needed for many jobs and careers.	1 2 3 4 5 6 7
12. To succeed in school, you need to be good in science.	1 2 3 4 5 6 7
13. To an educated person, it is as important to study major areas of science as classic literature.	1 2 3 4 5 6 7
14. Language and writing are an integral part of doing and learning inquiry-based science.	1 2 3 4 5 6 7
15. Science notebooks are an important component to inquiry-based science.	1 2 3 4 5 6 7
16. Science notebooks should be a reflection of what students do in science.	1 2 3 4 5 6 7
17. Science notebooks should be a reflection of what students have learned in science.	1 2 3 4 5 6 7
18. Students should use their science notebooks to record observations and procedures.	1 2 3 4 5 6 7
19. Students should use their science notebooks to make sense of the data.	1 2 3 4 5 6 7
20. Students should use their science notebooks to help them think critically about a topic.	1 2 3 4 5 6 7

21. Science notebooks should contain drawings with labels.	1 2 3 4 5 6 7
22. Science notebooks should contain data.	1 2 3 4 5 6 7
23. Science notebooks should contain procedures and steps.	1 2 3 4 5 6 7

24. Science notebooks should contain writing in the form of lists or notes.	1 2 3 4 5 6 7
25. Science notebooks should contain writing in the form of reflections.	1 2 3 4 5 6 7
26. Science notebooks should contain claims, evidence, and explanations.	1 2 3 4 5 6 7
27. Science notebooks should contain questions.	1 2 3 4 5 6 7
28. Science notebooks should contain correct information and facts.	1 2 3 4 5 6 7
29. It is important that students use correct grammar and spelling in their science notebooks.	1 2 3 4 5 6 7
30. Students should use the science notebook as a tool to reflect on their thinking.	1 2 3 4 5 6 7
31. Students should record in their science notebooks during a science activity.	1 2 3 4 5 6 7
32. Students should record in their science notebooks after a science activity.	1 2 3 4 5 6 7

33. Students have a basic understanding of the science notebook and how to use it.	1 2 3 4 5 6 7
34. Students are comfortable using their science notebook during a science activity.	1 2 3 4 5 6 7
35. Students are comfortable using their science notebook after a science activity.	1 2 3 4 5 6 7
36. Students generally know what to record in their science notebooks.	1 2 3 4 5 6 7
37. Students need assistance from the teacher to develop their science notebooks.	1 2 3 4 5 6 7
38. Modeling what is expected prior to students doing a science notebook entry is important.	1 2 3 4 5 6 7
39. Modeling after students have completed their own science notebook entry is important.	1 2 3 4 5 6 7
40. Students need explicit directions of what to put in their science notebooks.	1 2 3 4 5 6 7
41. It is okay for students to copy some information into their science notebooks to ensure that the information is correct.	1 2 3 4 5 6 7
42. Students should be allowed to develop the science notebook in a way that makes sense for them.	1 2 3 4 5 6 7

43. I feel comfortable using a science notebook.	1 2 3 4 5 6 7
44. I struggle with using a science notebook.	1 2 3 4 5 6 7
45. I feel comfortable modeling a science notebook entry for my students.	1 2 3 4 5 6 7
46. I feel comfortable teaching my students how to record in their science notebooks.	1 2 3 4 5 6 7
47. I struggle with knowing what a science notebook should look like.	1 2 3 4 5 6 7
48. I struggle in helping my students know what to record in their science notebooks.	1 2 3 4 5 6 7
49. I struggle in helping my students know how to use the notebook as a tool for their learning.	1 2 3 4 5 6 7
50. I understand the basic elements (date, title, questions, observations, data, etc.) that should be present in a notebook.	1 2 3 4 5 6 7
51. I understand how to use a science notebook to promote scientific thinking.	1 2 3 4 5 6 7
52. I understand how to use a science notebook to promote communication.	1 2 3 4 5 6 7
53. I learned how to use a science notebook as part of my teacher preparation program.	1 2 3 4 5 6 7
54. I learned how to use a science notebook by attending a workshop on science notebooks.	1 2 3 4 5 6 7

55. I learned how to use a science notebook by reading about science notebooks.	1 2 3 4 5 6 7
56. I learned how to use a science notebook by talking with colleagues.	1 2 3 4 5 6 7
57. Collaboration with colleagues around science notebooks is an essential component for my continued development of science notebooks.	1 2 3 4 5 6 7
58. Reading the latest books and research on science notebooks is an essential component for my continued development of science notebooks.	1 2 3 4 5 6 7
59. Workshops on science notebooks are an essential component for my continued development of science notebooks.	1 2 3 4 5 6 7

B. Preference choice items

To answer the following questions, select the one that most closely matches your view.

1 2 3 4

<----o----------o----------o----------o----->

1=I definitely would not do this.
2=I probably wouldn't do this.
3=I might do this.
4=I definitely would do this

How would you help your students understand how to develop and use science notebooks?

1. I'd keep a class notebook and model what it should look like and how to do it.	1 2 3 4
2. I'd show them examples of famous scientists' notebook pages.	1 2 3 4
3. I'd have other students share their notebook entries with the class.	1 2 3 4
4. I'd share science notebook entries from anonymous students.	1 2 3 4
5. I'd have students share their notebooks with a partner.	1 2 3 4

To assess student progress in science, I …

6. Collect and look at my students' science notebooks to assess progress of notebook development.	1 2 3 4
7. Collect and look at my students' science notebooks to assess progress of scientific understandings.	1 2 3 4
8. Look over my students' shoulders as they work in their science notebooks to assess progress of notebook development.	1 2 3 4
9. Look over my students' shoulders as they work in their science notebooks to assess progress of scientific understandings.	1 2 3 4
10. Share and discuss science notebook entries with a colleague.	1 2 3 4

When I need help with science notebooks and writing in science, I...

11. Observe other teachers and get their comments.	1 2 3 4
12. Ask other teachers to observe me talk with them.	1 2 3 4
13. Take a course on science notebooks.	1 2 3 4
14. Find out more about how scientists work.	1 2 3 4
15. Read about great scientists and the history of science.	1 2 3 4
16. Improve general teaching skills—such as how to motivate students.	1 2 3 4
17. Take a course of teaching science.	1 2 3 4
18. Look at examples of student work in science.	1 2 3 4
19. Learn more about the school's science curriculum.	1 2 3 4

20. Get (some or more) experience teaching science.	1 2 3 4

C. Judgment choice items

For each item, indicate your view using the following code:

1= They probably can do this.
2 = they probably cannot do this.
3=I don't know if they can do this.

Which of the following is probably within the capability of most seven- to eight-year-olds?

1. Recording their scientific observations.	1 2 3
2. Using drawings and labels to document their science experience.	1 2 3
3. Using words/sentences to document their science experience.	1 2 3
4. Writing a scientific claim.	1 2 3
5. Providing evidence to support their claim.	1 2 3
6. Writing an explanation that supports their claim.	1 2 3
7. Using the science notebook as a tool from which to pull important information.	1 2 3

Which of the following is probably within the capability of most ten- to eleven-year-olds?

8. Recording their scientific observations.	1 2 3
9. Using drawings and labels to document their science experience.	1 2 3
10. Using words/sentences to document their science experience.	1 2 3
11. Writing a scientific claim.	1 2 3
12. Providing evidence to support their claim.	1 2 3
13. Writing an explanation that supports their claim.	1 2 3
14. Using the science notebook as a tool from which to pull important information.	1 2 3

This is the end of survey. Thank you very much for your collaboration!!!

APPENDIX F: STUDENT ASSESSMENTS

Name _____

END-OF-MODULE ASSESSMENT FOR SOLIDS AND LIQUIDS

PERFORMANCE ASSESSMENT

Directions: Look at each object on the table. Write what you think the object is—solid or liquid—and tell why you think so.

1 crayon

2 lotion

3 soil

FOSS Solids and Liquids Module
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Can be duplicated for classroom or workshop use.

Summative Assessment
No. 1—Clark County Edition
Revised 5/03

OBM Investigation #4

Name _____

5. Draw a picture of a solid in one box. Draw a picture of a liquid in the other box.

Solid	Liquid

How are solids and liquids different?

_____

_____

_____

_____

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Summative Assessment
No. 7—Assessment Sheet

APPENDIX G: CONTENT ANALYSIS

Example of Content Analysis for Science Notebook – Whole Class

Student	# of pages	Date	Title	Focus Question	Sample	Drawing / Diagram	Labels	Writing	Graphic Organizer	Vocab.	Addresses Content	Describes Activity	Describes Feelings	Claim	Evidence	Explanation	Use of Because
#1																	
3.11A 5/25/2011	1	1	1		1		1	1		1				1			
3.1B 5/26/2011	1	1	1					1		1	1			1		1	1
3.2B 5/31/2011																	
3.2C 6/1/2011	2			1				1		1				1			
3.3 6/1/11																	
#2																	
3.1A 5/25/2011	1	1	1		1			1		1	1			1			
3.1B 5/26/2011	1	1	1					1		1	1			1		1	1
3.2B 5/31/2011																	
3.2C 6/1/2011	1			1				1		1	1			1		1	1
3.3 6/1/11	1			1				1						1			
#3																	
3.1A 5/25/2011	2	1	1		1	1		1		1	1			1	1		
3.1B 5/26/2011	1	1	1					1		1	1			1	1	1	1
3.2B 5/31/2011																	
3.2C 6/1/2011	2	1		1				1		1	1			1	1	1	1
3.3 6/1/11	1					1		1			1			1			
#4																	
3.1A 5/25/2011	1		1		1			1		1				1			
3.1B 5/26/2011	1	1	1					1		1	1			1		1	1
3.2B 5/31/2011																	
3.2C 6/1/2011																	
3.3 6/1/11																	

Example of Content Analysis for Science Notebook – Individual Student

Entry	Content	Date	Title	Focus question	Drawing/Diagram	Labels	Samples	Graphic Organizer	Writing	# of words	# of sentences	Sentence Starter	Materials included	Vocabulary	Addresses Content	Describes Activity	Describes Feelings	Observation	Claim aligned to content	Evidence +	Evidence -	Explanation +	Explanation -	Use of Because	Asks a question / states wondering	Entry incomplete
B1	mealworms	9/7/10	1		1	1			1	56	8	1	1	1	1			1								
B2	mealworms	9/9/10	1	1					1	31	5		1	1	1			1	1			1		1		
B3	mealworms	9/13/10	1	1	1		1		1	25	4				1			1	1			1		1		
B4	mealworms	9/22/10	1	1					1	27				1	1			1	1			1		1		
B5	mealworm lifecycle	9/29/10	1	1				1	1	46	9		1	1	1			1	1			1		1		
B6	beetle	10/1/10	1		1	1								1	1			1								
B7	waxworms	10/1/10	1	1					1	85	15	1		1	1			1							1	
B8	waxworm drawing	10/5/10	1		1	1								1	1											
B9	milkweed habitat	10/13/10	1		1	1							1													
B10	waxworms	10/13/10	1					1	1	10	3			1	1			1								
Subtotal for B1-10			10	5	5	4	1	2	7	280	44	2	4	8	9	0	0	8	4	0	0	4	0	4	1	0

APPENDIX H: SCORING GUIDES FOR PRE / POSTTESTS

Scoring Guide for Written Assessment

Question 1 – Draw a picture of a solid	
Score	**Attributes of Answer**
2	Draws a picture that clearly represents a solid
1	Draws a picture but it is not clear what it is
0	Doesn't draw a picture or draws an inaccurate representation of a solid
Question 2 – Draw a picture of a liquid	
3	Draws a picture of a liquid that indicates that liquids can spread out
2	Draws a picture that clearly represents a liquid
1	Draws a picture but it is not clear what it is
0	Doesn't draw a picture or draws an inaccurate representation of a liquid
Question 3 – Write how solids and liquids are different	
4	Describes the difference as: a solid keeps its shape but a liquid takes the shape of the container, a solid doesn't change if left out but a liquid evaporates/disappears, or can separate solids but not liquids
3	Provides a partial explanation of the differences using properties of solids and liquids
2	Gives an example of both a solid and a liquid, states that they have different properties but doesn't give further details or name the properties, or states a correct property of either a solid or a liquid but not the other
1	Provides an example of a solid or a liquid but not both
0	Gives a nonsense answer, inaccurate answer, an answer that cannot be deciphered clearly, or no answer at all

APPENDIX I: EXAMPLE OF DOMAIN ANALYSIS

Domain Analysis of science notebooks

X is a characteristic of science notebook entries	X is a way to record information in science notebooks	X is used to demonstrate understanding of scientific content in science notebook entries
- feelings - activity - observations - science content - conventions (date, title)	- writing - drawings / labels - including samples/papers	- claims - evidence - explanations

APPENDIX J: EXAMPLE OF TAXONOMIC ANALYSIS

Taxonomic Analysis – M2

Demonstration of Understanding	Entry	Evidence*
Claim	B2	“my mealworms did not chae a all”
	M6	“When I push the plungr the air has no wer to go so the air pushis the word up in the uthr barrel.”
	M7	“When I blow the balloon then wen I then it go’s evry wer” “When I let go the balloon it go’s strat”
	M8	“I think the air in sid the bubbles is hailping the bubbles t muv”
	E9	“A cornmeal is a solid
	E10	“that sume are hard sume are soft and try have ther an shap” “it’ll be all over you cud not because it wild full.”
Evidence	B2	“bce ckos I soit.”
	E9	“if we pudit in a vill it well be in litle pesses it wont be in litl or dig peeses”
Explanation	M6	“this hpins because the air tacks the spas.”
	M7	“because the air muvs it evry wer.” “it go’s because a strecing is holding it.”
	M8	“because it is triing to uskap the air is muving”
	E9	“because it hase it’s on shape” “it don’t chane ther shap”
	E10	“becaasue a liuid changis it’s shap”

***** All evidence are direct quotations from student entries and contain the student’s original grammar and spelling.

APPENDIX K: CHARACTERISTICS OF AN EXEMPLARY CONCLUSION

Characteristics of an Exemplary Basic Conclusion	**Comments**
☐ Answers the question that student has been investigating.	
☐ Provides evidence to support answer: o Observations (qualitative data) – i.e., what student has observed, such as the color of a plant's leaves (rather than what he has measured, such as the height of a plant). and / or o Comparison of test results (e.g., "The largest wheels made the go-carts go farther than the smallest wheels."). o Summary of measured (quantitative) data (i.e., reports specific measured data from the lowest and highest ends of the range, not all data: e.g., "4.5 cm wheels … go only 145 cm, but 11 cm wheels … go 276 cm.")	
☐ May discuss whether results of investigation support student's prediction.	

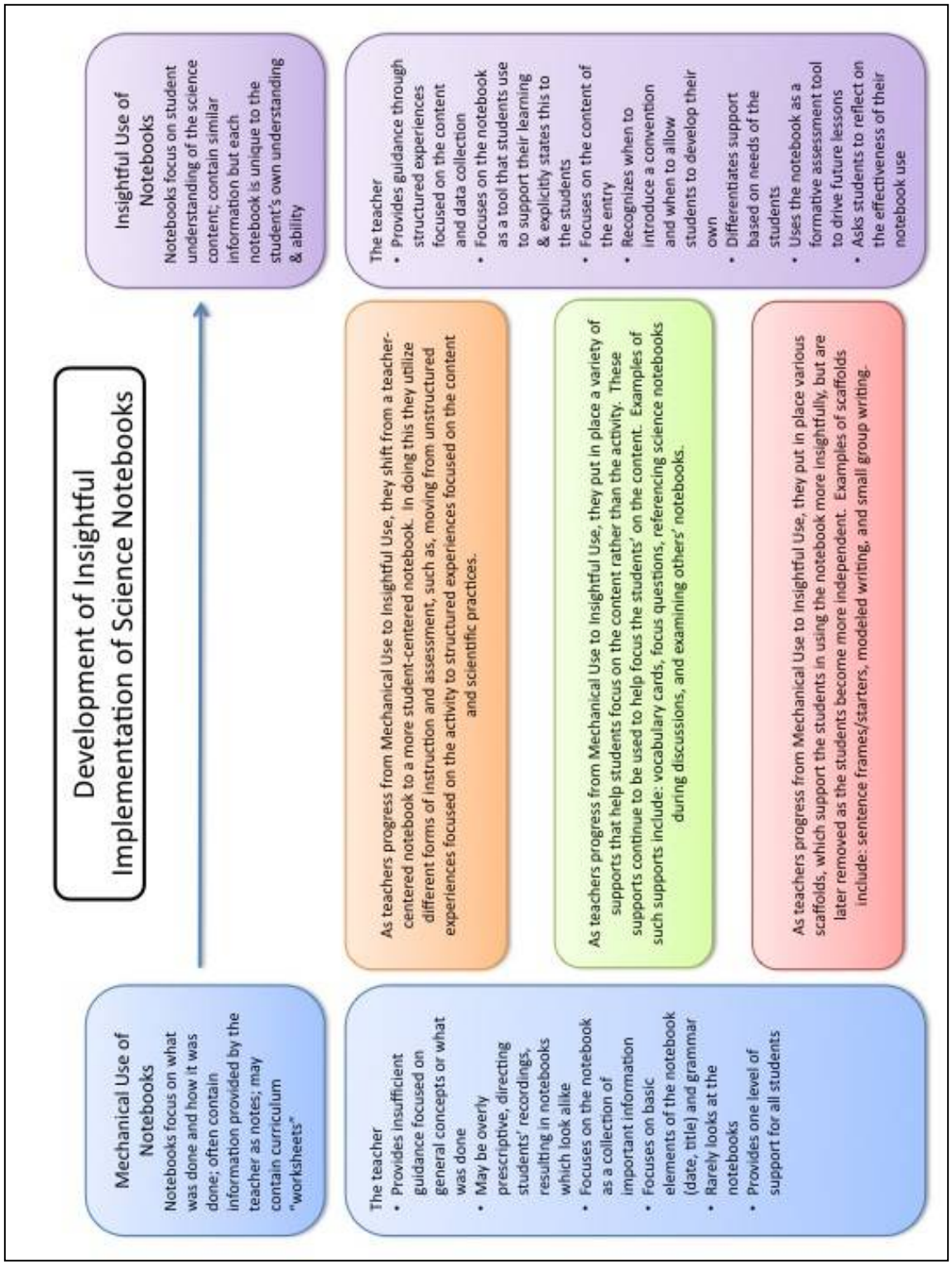
Adapted from *Writing in Science in Action* (Fulwiler, 2011)

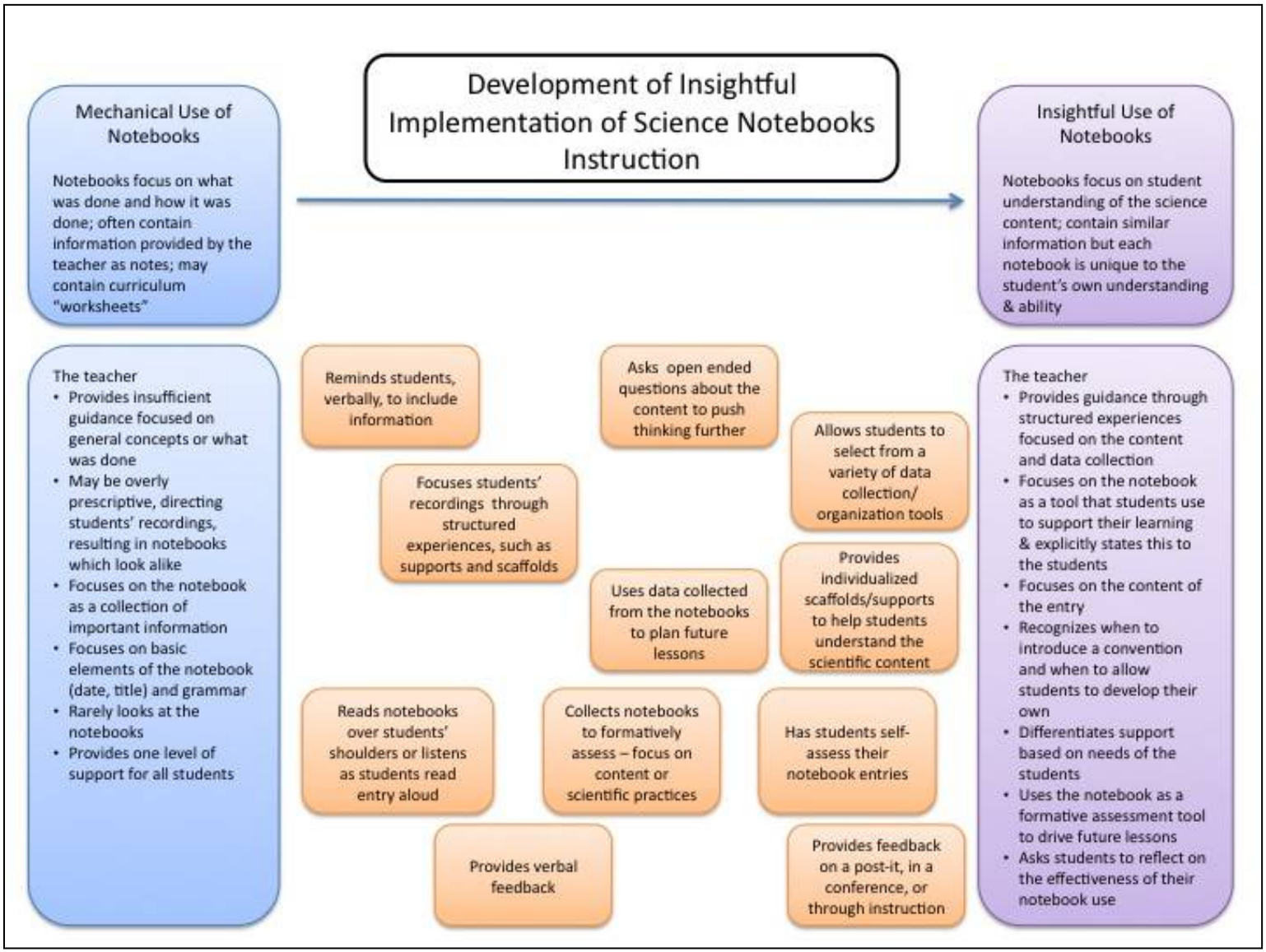
Characteristics of an Exemplary Complex Conclusion	**Comments**
☐ Answers in general way the question that student has been investigating.	
☐ Provides evidence to support answer: o Observations (qualitative data) – i.e., what student has observed, such as the color of a plant's leaves (rather than what he has measured, such as the height of a plant). and / or o Comparison of test results (e.g., "The largest wheels made the go-carts go farther than the smallest wheels."). o Summary of measured (quantitative) data (i.e., reports specific measured data from the lowest and highest ends of the range, not all data: e.g., "4.5 cm wheels … go only 145 cm, but 11 cm wheels … go 276 cm."). o May include comparative data (e.g., "In fact, the 20 cm wheels made the go-cart travel 131 cm farther [and/or "almost twice as far"] as the 4.5 cm wheels.").	
☐ Makes concluding statement that answers the question in a more generalized way (e.g., "Therefore, as the wheel size increases, the distance the go-cart travels increases." Or "So, the larger the wheels, the farther the distance the go-cart travels.").	
☐ Discusses whether results of investigation support student's prediction (i.e., what he thought would happen).	
☐ Addresses his initial reasoning (inferences or hypothesis) for why he thought the test results would happen. Explains how his thinking has or has not changed since he made his prediction.	
☐ Points out inconsistent or confusing data, if applicable, and what might have caused those results.	
☐ May include question(s) student wants to investigate because of the results.	

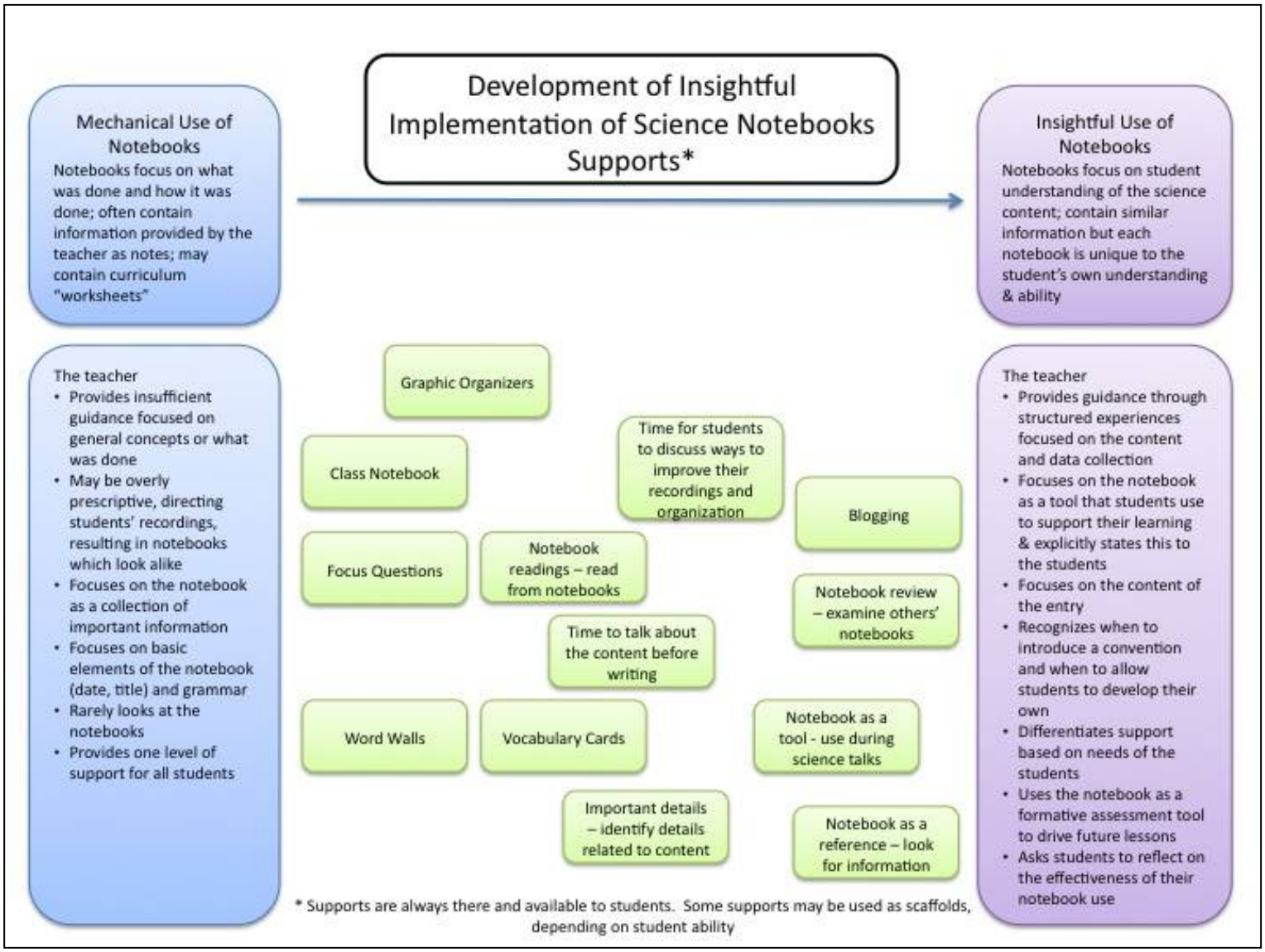
Adapted from *Writing in Science in Action* (Fulwiler, 2011)

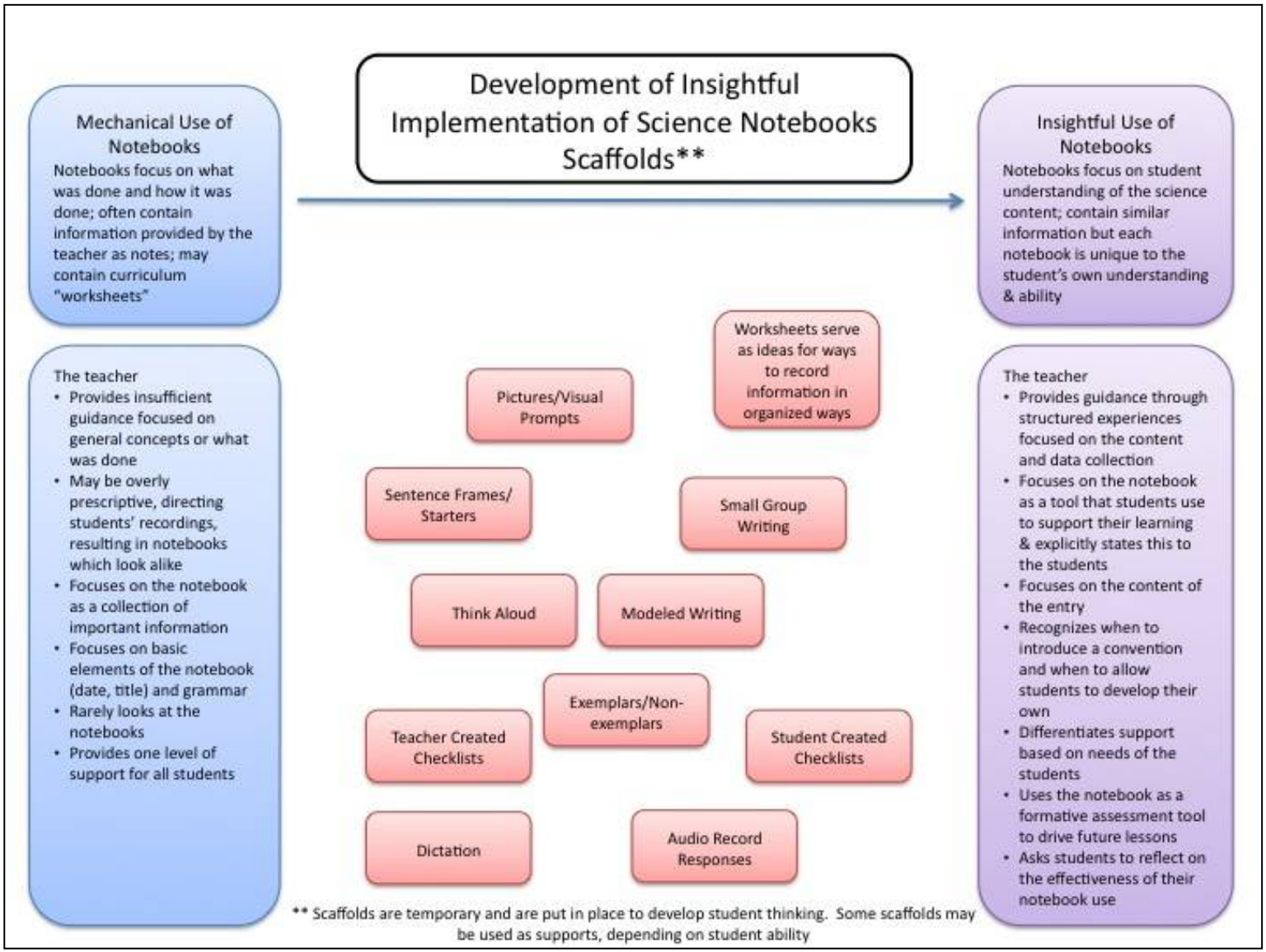
APPENDIX L: DIAGRAM OF SUBSTANTIVE THEORY

Development of Insightful Implementation of Science Notebooks




Development of Insightful Implementation of Science Notebooks Instruction
Mechanical Use of Notebooks
Notebooks focus on what was done and how it was done; often contain information provided by the teacher as notes; may contain curriculum "worksheets"
Insightful Use of Notebooks
Notebooks focus on student understanding of the science content; contain similar information but each notebook is unique to the student's own understanding & ability
The teacher
• Provides insufficient guidance focused on general concepts or what was done
• May be overly prescriptive, directing students' recordings, resulting in notebooks which look alike
• Focuses on the notebook as a collection of important information
• Focuses on basic elements of the notebook (date, title) and grammar
• Rarely looks at the notebooks
• Provides one level of support for all students
Reminds students, verbally, to include information
Asks open ended questions about the content to push thinking further
Allows students to select from a variety of data collection/ organization tools
Focuses students' recordings through structured experiences, such as supports and scaffolds
Uses data collected from the notebooks to plan future lessons
Provides individualized scaffolds/supports to help students understand the scientific content
Reads notebooks over students' shoulders or listens as students read entry aloud
Collects notebooks to formatively assess – focus on content or scientific practices
Has students self-assess their notebook entries
Provides verbal feedback
Provides feedback on a post-it, in a conference, or through instruction
The teacher
• Provides guidance through structured experiences focused on the content and data collection
• Focuses on the notebook as a tool that students use to support their learning & explicitly states this to the students
• Focuses on the content of the entry
• Recognizes when to introduce a convention and when to allow students to develop their own
• Differentiates support based on needs of the students
• Uses the notebook as a formative assessment tool to drive future lessons
• Asks students to reflect on the effectiveness of their notebook use


Development of Insightful Implementation of Science Notebooks Supports*
Mechanical Use of Notebooks
Notebooks focus on what was done and how it was done; often contain information provided by the teacher as notes; may contain curriculum "worksheets"
Insightful Use of Notebooks
Notebooks focus on student understanding of the science content; contain similar information but each notebook is unique to the student's own understanding & ability
The teacher
• Provides insufficient guidance focused on general concepts or what was done
• May be overly prescriptive, directing students' recordings, resulting in notebooks which look alike
• Focuses on the notebook as a collection of important information
• Focuses on basic elements of the notebook (date, title) and grammar
• Rarely looks at the notebooks
• Provides one level of support for all students
Graphic Organizers
Class Notebook
Time for students to discuss ways to improve their recordings and organization
Blogging
Focus Questions
Notebook readings – read from notebooks
Notebook review – examine others' notebooks
Time to talk about the content before writing
Word Walls
Vocabulary Cards
Notebook as a tool - use during science talks
Important details – identify details related to content
Notebook as a reference – look for information
The teacher
• Provides guidance through structured experiences focused on the content and data collection
• Focuses on the notebook as a tool that students use to support their learning & explicitly states this to the students
• Focuses on the content of the entry
• Recognizes when to introduce a convention and when to allow students to develop their own
• Differentiates support based on needs of the students
• Uses the notebook as a formative assessment tool to drive future lessons
• Asks students to reflect on the effectiveness of their notebook use
* Supports are always there and available to students. Some supports may be used as scaffolds, depending on student ability


Development of Insightful Implementation of Science Notebooks Scaffolds**
Mechanical Use of Notebooks
Notebooks focus on what was done and how it was done; often contain information provided by the teacher as notes; may contain curriculum "worksheets"
The teacher
• Provides insufficient guidance focused on general concepts or what was done
• May be overly prescriptive, directing students' recordings, resulting in notebooks which look alike
• Focuses on the notebook as a collection of important information
• Focuses on basic elements of the notebook (date, title) and grammar
• Rarely looks at the notebooks
• Provides one level of support for all students
Pictures/Visual Prompts
Worksheets serve as ideas for ways to record information in organized ways
Sentence Frames/ Starters
Small Group Writing
Think Aloud
Modeled Writing
Exemplars/Non-exemplars
Teacher Created Checklists
Student Created Checklists
Dictation
Audio Record Responses
Insightful Use of Notebooks
Notebooks focus on student understanding of the science content; contain similar information but each notebook is unique to the student's own understanding & ability
The teacher
• Provides guidance through structured experiences focused on the content and data collection
• Focuses on the notebook as a tool that students use to support their learning & explicitly states this to the students
• Focuses on the content of the entry
• Recognizes when to introduce a convention and when to allow students to develop their own
• Differentiates support based on needs of the students
• Uses the notebook as a formative assessment tool to drive future lessons
• Asks students to reflect on the effectiveness of their notebook use
** Scaffolds are temporary and are put in place to develop student thinking. Some scaffolds may be used as supports, depending on student ability

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