Promoting Pedagogical Design Capacity through Teachers' Narratives

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A paper presented at the April 2007 annual meeting of the National Association for Research in Science Teaching, New Orleans.

Acknowledgements

This research is funded by a Presidential Early Career Award for Scientists and Engineers (PECASE) grant from the National Science Foundation, REC grant #0092610, as well as a Centers for Learning and Teaching (CLT) grant #0227557. However, any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors. We greatly appreciate the interest and cooperation of the teachers who made the research reported here possible. We also thank the CASES research group at the University of Michigan—in particular, Julie Smithey—and members of the Center for Curriculum Materials in Science for their help in thinking about these issues.

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Abstract: Teachers need to develop the ability to adapt curriculum materials. This paper explores the ways in which two elementary teachers who were asked to write narratives about their use of particular lesson plans described the changes they made to the curriculum materials, and how the construction of these narratives contributed to their development as professionals. The results indicate that Maggie draws extensively on her knowledge of and experiences with her students, as well as other knowledge, experiences, and resources, to make productive changes to lesson plans to account for her students' prior knowledge and abilities. Catie, on the other hand, bases her curricular adaptations on her learning goals for students—but Catie's learning goals are not always well-aligned with the learning goals espoused by the curriculum materials. The process of writing these narratives served to some extent as a professional development experience for the teachers. Maggie became more aware of and articulate about the role of modifying curriculum materials in her professional identity. Catie experiences a more fundamental shift toward a belief that modifying curriculum materials is acceptable, and also describes a shift in her perspective about the relative importance of content and inquiry-related learning goals. The paper concludes with a discussion of implications for the design of teacher education, professional development, and educative curriculum materials.

Introduction

How do elementary teachers go about the process of using existing science curriculum materials to guide their instruction? How do they embark in the "pedagogical design" (Brown, in press) in which any teacher must engage? How do they adapt reform-based, inquiry-oriented science curriculum materials to meet their needs? What kinds of curricular adaptations do they make, and on what do they base their decisions? How do they describe these decisions in materials aimed at supporting new teachers' learning? Questions like these spurred the research reported here.

Curriculum materials play a central role in guiding teachers' practice (Remillard, 2005) especially for newer teachers (Grossman & Thompson, 2004). Teachers need to adapt even high-quality curriculum materials to better support their own students' learning (Barab & Luehmann, 2003; Baumgartner, 2004). Adaptations may be based on aspects of the teachers' contexts, their learning goals, and their knowledge, beliefs, identities, and orientations (e.g., Drake & Sherin, 2006; Pintó, 2005; Remillard & Bryans, 2004; Valencia, Place, Martin, & Grossman, 2006). Teachers' ability to employ personal resources as well as resources embedded in the materials themselves to make productive changes to curriculum materials is referred to as their *pedagogical design capacity* (Brown, in press; Brown & Edelson, 2003). Some teachers make productive changes to curriculum materials that support and enhance the intent of the curriculum materials while other teachers—for example, those who do not deeply understand the rationales behind reforms promoted in some materials—may make unproductive changes (Collopy, 2003; Remillard, 1999; Schneider & Krajcik, 2002). Of course, some teachers view curriculum materials as providing a script, and thus do not see curricular adaptation as a part of their job (Bullough, 1992; Eisenhart et al., 1998). This and other dimensions constitute a teacher's *curricular role identity*, which frames his or her perspective on using curriculum materials (Forbes & Davis, 2007).

Elementary teachers face enormous challenges in teaching science. These challenges are associated with the very high number of subjects they are responsible for (including all disciplines within the broader field of science), their typically limited science subject matter knowledge (Abell, 2007; Anderson & Mitchener, 1994; Davis, Petish, & Smithey, 2006; NRC, 2007) and understanding of scientific inquiry (e.g., Bryan, 2003; NRC, 2007), their typically low confidence in teaching science (Cochran & Jones, 1998), and the limited amount of instructional time dedicated to science in most elementary schools in the US and in some other countries (Appleton, 2007). Because of these and other challenges, elementary teachers may depend heavily on curriculum materials in science. Yet also because of these and other challenges, these teachers may at the same time be more likely to adapt curriculum materials in a way that moves away from the curriculum developers' intent.

Educative curriculum materials are curriculum materials that are designed with the intention of promoting teacher learning as well as student learning. Researchers and curriculum developers hypothesize that educative curriculum materials can promote teachers' learning and identity development (Ball & Cohen, 1996; Davis & Krajcik, 2005). Middle school teachers who use educative project-based science curriculum materials, for example, develop improved pedagogical content knowledge (Schneider & Krajcik, 2002). We hypothesize that situating the supports within specific lessons, for example through teacher narratives about the lesson, may be especially useful, since teacher learning is so grounded in practice (Putnam & Borko, 2000). Preservice elementary teachers who use such grounded narrative features within educative curriculum materials as a part of a course assignment focus needed attention on issues like attending to students' ideas as well as on their own development as teachers (Dietz & Davis, accepted pending revisions).

Educative curriculum materials can be designed with supports in place to promote teachers' pedagogical design capacity (Brown, in press; Brown & Edelson, 2003)—that special ability to use curriculum materials effectively. For example, educative science curriculum materials can incorporate suggestions for making lessons more or less student-directed or for addressing other concerns teachers may have (Davis, Smithey, & Petish, 2004), thus providing resources within the curriculum materials themselves to support teachers in making productive changes. By providing rationales for instructional recommendations being made by the curriculum materials, educative curriculum materials can help promote the development of more sophisticated knowledge and beliefs, changes in orientation, and/or shifts in curricular role identity that would in turn promote more effective use of the curriculum materials (Ball & Cohen, 1996; Davis & Krajcik, 2005).

There is, however, the pragmatic problem of how we attain quality educative curriculum materials. In particular, if there is benefit of incorporating situated and authentic accounts of how teachers use and modify curriculum materials into the materials themselves, as educative features for other teachers to use and learn from, then how can those accounts be generated? If teachers write these accounts, are the changes they describe likely to be productive or counter-productive? Some evidence suggests that the alignment between the teachers' orientations and those espoused by the curriculum materials will affect the changes the teachers would describe (Collopy, 2003; Remillard, 1999; Remillard & Bryans, 2004). Furthermore, is it beneficial for teachers to write

such accounts, as a professional development experience for themselves? Some evidence suggests that it might be (e.g., Florio-Ruane, 1999) though these studies have not grounded the writing of narratives in the use of curriculum materials.

Purpose of the Research

To explore these questions, and to gain more insight into elementary teachers' pedagogical design capacity, we engaged two elementary teachers in the professional development task of writing narratives describing how they used and adapted curriculum materials, with the explicit intent of incorporating their narratives into our educative curriculum materials. We hoped to benefit from their wisdom, and to provide a professional development and leadership experience for the teachers at the same time.

Our first research question is, *How do elementary teachers construct narratives for educative curriculum materials?* We were interested in what kinds of curricular adaptations teachers describe. We were also interested in what knowledge, experiences, and resources teachers draw on in making the decisions that they report in the narratives. We were especially interested in these issues with regard to elementary teachers since elementary teachers face numerous challenges in teaching science, including limited subject matter knowledge and pedagogical content knowledge and low confidence (Anderson & Mitchener, 1994; Cochran & Jones, 1998). Our second major question is, *How does the construction of narratives for educative curriculum materials contribute to teacher development?* We were interested in what benefits the teachers believed they obtained from this experience. We were also interested in evidence of how writing narratives promoted the development of teachers' knowledge, identity, and eventually, their pedagogical design capacity.

Methods

Two teachers, Maggie and Catie, provide illustrative and contrastive cases. We explore how Maggie connected her changes to a science unit to her knowledge of her students, and how Catie's changes were connected to her learning goals for her students. We also explore how these teachers (and we) perceived the process of writing narratives to contribute to their professional growth. In the following sections, we describe Maggie and Catie first. We then describe the educative curriculum materials their narratives were intended to accompany. We describe the professional development and data collection experience, and then how we analyzed the data sources.

Participants

Maggie and Catie participate in our longitudinal study following their experiences as beginning elementary teachers (e.g., see Beyer & Davis, in review; Forbes & Davis, in review; Stevens & Davis, 2007). Each of these teachers graduated from the same teacher preparation program, although they graduated in different years. Each took a version of an elementary science methods course taught by the first author.

Maggie started teaching in January 2000 and is the most experienced teacher in our longitudinal study. Our intensive data collection with Maggie started in Fall 2002. During that school year and the following one, Maggie taught fourth grade at a private Catholic school in a suburb of a large city in the Midwest; her previous teaching experiences had included one

semester in an urban district and a couple of years at a different suburban Catholic school, both in or outside a different large Midwestern city. When Maggie was in her fifth full year of teaching, she achieved a long-term goal and moved to a very large, ethnically and culturally diverse, urban school district, where she still teaches third grade. Maggie is working on a masters degree in special education and hers is an inclusion classroom. Maggie is viewed as a language arts expert in her school, and at the time of this study was leading a professional development experience in a math curriculum for other teachers at her school, as well.

Catie began teaching in Fall 2002. Catie spent her first year teaching sixth grade at a Catholic school in a suburb outside a major Midwestern city. Subsequently, she has taught second grade at a different Catholic school in a suburb nearby. Her school is mostly white and is relatively homogeneous with regard to socioeconomic status. Catie typically has approximately 30 second-graders in her classroom; perhaps not coincidentally, Catie has started to move *away* from experimentation over time. Catie is pursuing a masters degree in science education and seems to self-identify as a science teacher, not (solely) a generalist.

A third teacher from our longitudinal study started this project, but due to conflicting demands on her time, dropped out midway through. Her data is excluded from this report.

CASES Educative Curriculum Materials

As a part of their work with us in our longitudinal study, the teachers use an online learning environment we developed and teach at least one of our educative, inquiry-oriented science units each year. CASES (http://cases.soe.umich.edu) is a technology-mediated learning environment intended to support preservice and new elementary teachers' learning with regard to inquiry-oriented science teaching. The CASES materials emphasize three essential features of inquiry—asking and answering scientific questions, constructing evidence-based explanations, and communicating and justifying findings—building on the National Research Council's characterization of inquiry (NRC, 2000) and further calls for reform (NRC, 2007). Some CASES units—like the weather unit with which Maggie worked—have relatively uniform emphasis on all three of these essential features. Others—like the plants unit with which Catie worked—emphasize one inquiry practice in particular; in the plants unit, the emphasis is on evidence-based explanations, instantiated here as supporting claims with evidence. The lessons within the weather and plants units are summarized briefly in Tables 1 and 2.

Lesson Name	*Summary of Lesson*
Lesson 1: Establishing Daily Weather Observations ("Weather Observations")	The teacher helps students establish what data they will collect during daily weather observations throughout the unit.
Lesson 2: What Causes the Wind? ("Wind")	Students observe and explore wind and air and conduct an investigation about wind formation.
Lesson 3: Where Do Puddles Go? ("Puddles")	Students investigate what happens to puddles by observing evaporation that takes place in a paper plate and measuring the remaining water.
Lesson 4: Cloud Formation	Students create a model of a cloud in its early stages of its formation, demonstrating condensation using salt as condensation nuclei.
Lesson 5: What Causes the Seasons? ("Seasons")	Students explore how the sun and the earth interact to cause seasons, using a light source to represent the sun and a Styrofoam ball to represent the earth.

Table 1: Summary of Lessons in CASES Weather Unit for Grades 3-5

Lesson Name	*Summary of Lesson*
Lesson 1: Finding Seeds in Fruits ("Finding Seeds")	Students investigate where seeds are located in plants.
Lesson 2: Grouping Seeds	Students compare and contrast seeds from different kinds of plants.
Lesson 3: Looking at How Seeds Move ("How Seeds Move")	Students investigate different methods of seed dispersal and their importance to the survival of plants' offspring. Students observe the features of different seeds.
Lesson 4: Observing Seed Parts ("Seed Parts")	Students observe the parts of a seed and discuss the parts of the seed that enable germination.
Lesson 5: Do Plants Need Sunlight?	Students explore the importance of the sun for a plant's survival by conducting an investigation. Each group of students covers parts of plants' leaves with black construction paper and observes the plants over several days. This lesson serves to model the process of investigation in preparation for the next lessons.
Lesson 6: Asking Questions About Plants	Students ask questions about plants that they will later answer through an investigation that they design.
Lesson 7: Investigating Plants	Students design and conduct an investigation to answer a question the class raised during the previous lesson. Students share the results of their investigation as well as what they have learned about plants and about how to design and conduct a scientific investigation.
Lesson 8: Field Trip	Students prepare questions they have about the journey of plants from a farm to consumers. They visit a farm or grocery store to have their questions answered.

Table 2: Summary of Lessons in CASES Plants Unit for Grades K-2

CASES and its curriculum materials incorporate educative elements such as supports for how and why one might engage in inquiry-oriented science teaching practices, guidance regarding students' ideas, science background knowledge, and a reflective journal space with prompts for reflection (Davis, Smithey, & Petish, 2004). Of most relevance here are the narrative images of inquiry, one of the types of educative elements in CASES. These narratives involve fictional—and, as of the project described in this paper, also real—preservice and new teachers (Dietz & Davis, accepted pending revisions; Smithey & Davis, 2004). CASES provides a brief descriptive profile for each of the Image teachers. For example, Peg is described as a fictional first grade teacher in her second year of teaching who wants to improve her ability to support her young students in developing deep understandings of science content using inquiry. The profiles that Maggie and Catie wrote about themselves and their focus are provided in Figures 1 and 2.

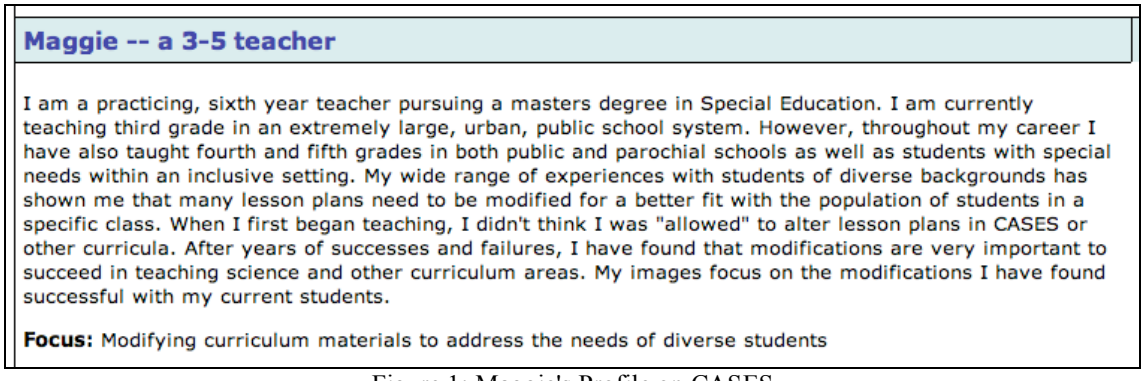
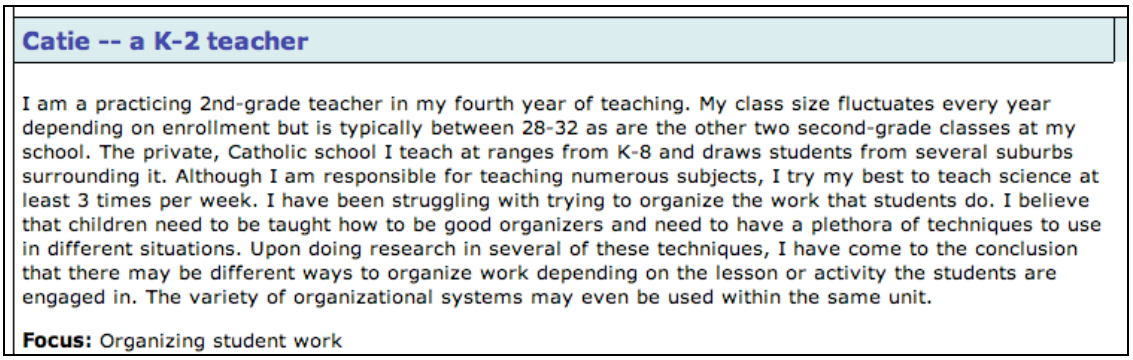


Figure 1: Maggie's Profile on CASES



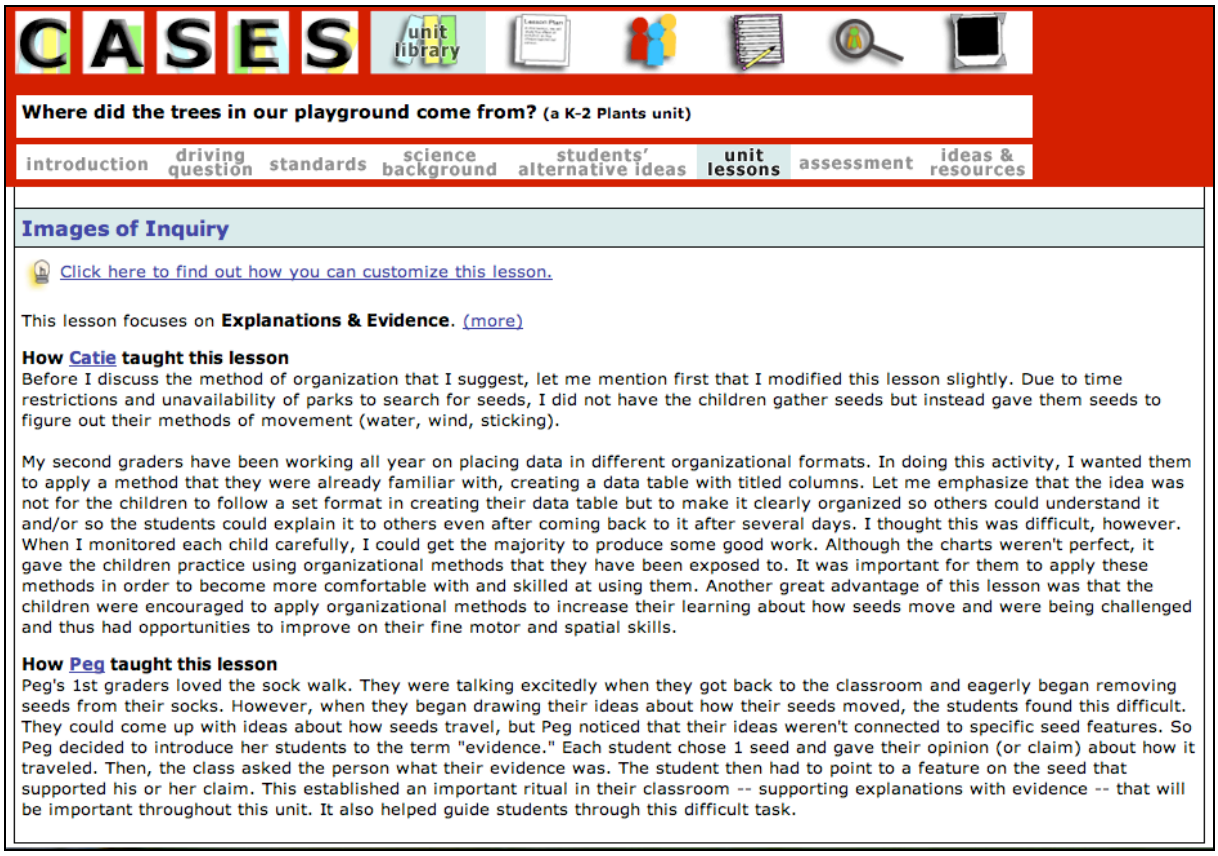
Catie -- a K-2 teacher

I am a practicing 2nd-grade teacher in my fourth year of teaching. My class size fluctuates every year depending on enrollment but is typically between 28-32 as are the other two second-grade classes at my school. The private, Catholic school I teach at ranges from K-8 and draws students from several suburbs surrounding it. Although I am responsible for teaching numerous subjects, I try my best to teach science at least 3 times per week. I have been struggling with trying to organize the work that students do. I believe that children need to be taught how to be good organizers and need to have a plethora of techniques to use in different situations. Upon doing research in several of these techniques, I have come to the conclusion that there may be different ways to organize work depending on the lesson or activity the students are engaged in. The variety of organizational systems may even be used within the same unit.

Focus: Organizing student work

Figure 2: Catie's Profile on CASES

Short vignettes about one, two, or three of these teachers are incorporated in each lesson on CASES. Each vignette describes how the Image teacher taught the lesson. For example, in one lesson, fictional image teacher Peg introduced a ritual of providing evidence for claims into her first-grade classroom. This image from Peg and an example from Catie for the same lesson are provided in Figure 3.The narrative images describe real challenges new elementary teachers face, such as anticipating students' ideas (Smith & Neale, 1989) or understanding the science content themselves (Anderson & Mitchener, 1994).



CASES unit library

Where did the trees in our playground come from? (a K-2 Plants unit)

introduction | driving question | standards | science background | students' alternative ideas | unit lessons | assessment | ideas & resources

Images of Inquiry

Click here to find out how you can customize this lesson.

This lesson focuses on **Explanations & Evidence**. (more)

How Catie taught this lesson

Before I discuss the method of organization that I suggest, let me mention first that I modified this lesson slightly. Due to time restrictions and unavailability of parks to search for seeds, I did not have the children gather seeds but instead gave them seeds to figure out their methods of movement (water, wind, sticking).

My second graders have been working all year on placing data in different organizational formats. In doing this activity, I wanted them to apply a method that they were already familiar with, creating a data table with titled columns. Let me emphasize that the idea was not for the children to follow a set format in creating their data table but to make it clearly organized so others could understand it and/or so the students could explain it to others even after coming back to it after several days. I thought this was difficult, however. When I monitored each child carefully, I could get the majority to produce some good work. Although the charts weren't perfect, it gave the children practice using organizational methods that they have been exposed to. It was important for them to apply these methods in order to become more comfortable with and skilled at using them. Another great advantage of this lesson was that the children were encouraged to apply organizational methods to increase their learning about how seeds move and were being challenged and thus had opportunities to improve on their fine motor and spatial skills.

How Peg taught this lesson

Peg's 1st graders loved the sock walk. They were talking excitedly when they got back to the classroom and eagerly began removing seeds from their socks. However, when they began drawing their ideas about how their seeds moved, the students found this difficult. They could come up with ideas about how seeds travel, but Peg noticed that their ideas weren't connected to specific seed features. So Peg decided to introduce her students to the term "evidence." Each student chose 1 seed and gave their opinion (or claim) about how it traveled. Then, the class asked the person what their evidence was. The student then had to point to a feature on the seed that supported his or her claim. This established an important ritual in their classroom -- supporting explanations with evidence -- that will be important throughout this unit. It also helped guide students through this difficult task.

Figure 3: Two Sample Images of Inquiry on CASES

Engaging Teachers in Writing Narrative Images of Inquiry

Maggie and Catie agreed to participate in a professional development experience in which they would write narratives describing their use of lessons within CASES units. They were told that the narratives they wrote would be incorporated into our educative curriculum materials. The experience took about 6-8 weeks during Summer 2006. Maggie and Catie worked in parallel and were able to comment on one another's written narratives.

We engaged the teachers in an iterative series of interviews and online work using a discussion space built into CASES. The interviews and online work were designed to support the teachers in engaging in the process of selecting a focus for their narratives, refining that focus, exploring ways of relating the focus to the lesson plans, and drafting and refining the narratives themselves. The teachers responded to questions we asked, either in the interviews or online, and were able to refer to their written responses as they drafted their images. In addition, the narratives were posted in the online space. As teachers made decisions to refine their narratives, they could make those revisions directly. We kept track of each version of the narratives and connected these to the written reflections of the teachers in the online discussion space.

Each teacher was interviewed four times via phone, with three of the interviews conducted with the teachers individually and one interview conducted with them together. Some of these interviews served as work sessions for developing and refining the images. The first author conducted all of the interviews. During the first individual interview, the teachers were asked to describe the factors motivating them to participate in the project, their ideas concerning the theme they might use for writing their images, their experiences with teaching the unit that they had chosen, and their ideas for what they might include in their teacher profile. The second individual interview asked the teachers to describe their ideas about how to refine each lesson in the unit with regard to their theme and why they thought their refinements might be productive (including a discussion of advantages and disadvantages of the changes) as well as how they had come up with their ideas. During the combined interview, the teachers were introduced to one another via a three-way telephone conversation, and each described her teaching context as well as her focus for her narratives. Due to scheduling difficulties, the combined interview took place two days after the second individual interview with Catie, and immediately prior to the second individual with Maggie. The fourth interview, conducted individually, asked teachers to describe any benefits they had received from their experience in writing the images, factors impacting their thinking, and any feedback they had on how the image-writing process could be improved.

The teachers received specific prompts once via email and three times via the online discussion space to facilitate their thinking about how to draft their images. More specifically, the teachers were first asked initially via email to define the theme they had chosen for their images by responding to prompts that asked them to explain the key terms and big ideas related to their theme. Subsequently, the teachers received prompts via the online discussion space, asking them to draft a profile of themselves that described their teaching background, context, and the theme they had chosen for their narratives. They were then given additional online prompts to foster their reflection upon their previous experiences in teaching the unit that they would be writing images for and to assist them in thinking about how their theme related to each lesson in the unit. After responding to these prompts, the teachers were provided with another set of online prompts that assisted them in narrowing their ideas that they had brainstormed for each

lesson so that they would address one specific issue or idea in each lesson related to their theme and explain their rationale for their ideas. Finally, the teachers received guidelines for how to actually go about drafting their initial set of images. Appendix A details the exact prompts that teachers received via email and the online discussion space. Once the teachers posted an initial set of images online, the drafts were iteratively revised, following frequent feedback from the first author and the other teacher participant.

One early task thus involved selecting a focus for the narratives. Maggie chose to focus on making modifications to lesson plans in a unit on weather in reaction to her students and their ideas and experiences. Catie chose to focus on supporting her students in and through organization. As noted above, Catie's narratives were associated with a unit on plants.

Data Sources and Analysis

Thus, our data sources for this study include a series of four interviews with each teacher, their written responses to the questions posed online about their theme and about each lesson, their self-generated "profile" describing themselves as teachers, the drafts of their images, their comments on one another's images and responses to one another's comments, a single journal entry written at the end of the process responding to questions about the theme the teachers selected, and email exchanged during the process. In our analyses here, we draw most heavily on the interview data and the images the teachers developed, as well as the text they wrote in the online discussion space. These data sources are supplemented by the extensive data—interviews, system logs, written reflections, email exchanges, and some classroom observations—from our ongoing longitudinal study (see, e.g., Beyer & Davis, in review; Forbes & Davis, in review; Stevens & Davis, 2007).

We developed guiding analytic questions to guide our coding and analysis of these data. These analytic questions focus on describing the teachers' curricular adaptations, the basis for those adaptations, their initial perceptions of the benefits of the project, their final perceptions of the benefits of participating in the project, and our own perceptions of the benefits to them. These analytic questions guided the design of our coding schemes, which were developed primarily through open coding. These coding schemes incorporate descriptors of the curricular adaptations themselves (see Table 3), the basis for the curricular adaptations (see Table 4), and the teachers' development as professionals (see Table 5).

Coding Descriptor and Definition	*Example*
Change (general): Teacher makes a general change to the lesson, not characterized by one of the more specific codes	Make a bulletin board
Add, remove, or change investigation or hands-on experience: Teacher adds a new hands-on activity, or removes one from the written lesson plan	Addition of a lesson involving making and using a barometer
Add, remove, or change text: Teacher reads a science tradebook, text, or relevant story, or excludes one recommended by the written lesson plan	Addition of a book by Vicki Cobb
Add, remove, or change in data-gathering and/or data-recording: Teacher changes the approach used for data gathering or data recording	Removal of "humidity" as a measurement to record
Add, remove, or change scaffolding: Teacher provides additional support for students or provides less support than recommended in the written plan	Inclusion of examples of instances in which clarity or drawing matters
Add, remove, or change discussion: Teacher adds a new whole-class discussion, or removes or makes substantive change to existing discussion	Addition of discussion of an unusual weather event
Add, remove, or change worksheet: Teacher adds, removes, or changes a worksheet, in a way not specified by one of the more specific codes.	Substitution of a "foldable" in place of a worksheet
Add or remove entire lesson: Teacher adds a lesson not included in CASES unit, or removes a CASES lesson	Removal of CASES "sock walk" to pick up seeds
Change in sequence: Teacher moves lessons within the CASES unit	Shifting evaporation lesson

Table 3: Coding Scheme for Description of Curricular Adaptations

Coding Descriptor and Definition	*Example*
<u>*Knowledge and Beliefs*</u>	
PCK: Includes knowledge of student ideas, instructional representations, etc.	Identification of "wind is caused by God" as child's alternative idea
Knowledge of students: Knowledge regarding students as individuals, groups of students, students' knowledge level in general, students' community and family contexts, etc.	Recognition that most of one's students' families do not have computers at home
Subject matter knowledge: Knowledge of science content and inquiry	Knowledge about air pressure
General pedagogical or educational knowledge: Knowledge of appropriate instructional strategies, educational psychology, etc.	Identification of "pre-teaching a difficult concept" as an instructional strategy to use
Knowledge of school context: Knowledge of contextual issues related to school and schooling, such as knowledge of previous and future grades' foci, collegial norms, etc.	Understanding of what happens with regard to science instruction in previous grades
Curricular knowledge: Knowledge of what topics should be or are taught, scope and sequence, curriculum materials, etc.	Understanding of standards set by school for science outcomes
Learning goals: Teachers' own learning goals for the students	Careful observation as a skill to develop
<u>*Experiences*</u>	
Current teaching experiences: Experiences in current classroom teaching current unit	Experience this week with Puddles lesson
Previous teaching experiences: Experiences in previous classrooms, grades, and schools	Experience in suburban school
Coursework: Experiences related to previous coursework in education or science subject matter	Experience in masters classes
Professional development experiences: Experiences with previous or current professional development provided by school or sought on own	Attendance at a PD workshop for math curriculum
<u>*Resources*</u>	
Curriculum materials (in general): Lesson plans, unit plans, worksheets, activities, etc.	Lesson ideas from NSTA publication *Science and Children*
CASES: Lesson plans, unit plans, and other material in CASES	Existing images of inquiry in CASES
Student texts: Science tradebooks, textbooks, fiction, etc.	Vicki Cobb's books blending informational text and investigations
Teacher texts: Texts intended for teachers	Dinah Zikes' books about foldables
Colleagues: Opportunity to co-plan, get guidance from others, etc.	Working with grade-level colleagues
Time: Time necessary to plan lessons, assess students, etc.	Time for planning
<u>*Other:*</u> *Pragmatics or logistics:* Materials, room set-up, scheduling, etc.	Availability of equipment

Table 4: Coding Scheme for Description of Basis of Curricular Adaptations

Coding Descriptor and Definition	*Example*
Reflection: Includes anticipatory (planning) reflection and retrospective reflection on instruction, as well as reflection-in-action	General statement about the desire to reflect on one's teaching
Opportunity for teacher collaboration: Includes consideration of ways in which teachers can work together to improve instruction	Appreciation of opportunity to work with another teacher (i.e., Maggie or Catie)
Professional development in science teaching: Includes consideration of ways in which one can improve one's own science teaching	Statement that CASES is one's only professional development opportunity in science
Improved science teaching: Includes consideration of how one's teaching is improving or has improved	Statement that instruction this year was improved, with evidence that students understood concepts better
Awareness of aspect of self: Includes awareness of an aspect of one's identity as a teacher and/or awareness of one's own strengths and weaknesses	Awareness of the extent that one modifies existing curriculum materials
Provide benefit to others: Includes perspective that by writing images or providing other leadership, one can support other teachers	Expression of desire to help newer teachers
Gain recognition as a leader: Includes acknowledgement of one being seen as a leader by administrators or other teachers	Discussion of leadership of math curriculum professional development
General improvement in self (not specific to science teaching): Includes other aspects of improvement	Becoming a better writer

Table 5: Coding Scheme for Description of Development as Professional

After coding the data and compiling and synthesizing the codes, we developed preliminary cases to describe each teacher. We then engaged in an iterative process moving between the data and the case to refine the claims made in each case.

Results

We present results related to these two teachers and on what they focused their attention in writing their images, what kinds of curricular adaptations they made to the CASES lessons, on what they based those curricular adaptations, and what we can infer about how this process affected them as professionals, including how it affected their pedagogical design capacities. We turn first to a discussion of Maggie's case.

Maggie's Theme: Modification of Curriculum Materials

Maggie chose to focus her images on the theme of "modification." In an email, as she was in the process of narrowing in on a choice for a focus, Maggie wrote:

> I might think something about modification for age levels or ability levels. Teaching weather to 4th grade was much different than 3rd grade....or it might have been the economics of the school [in the suburb I used to teach in] vs. [in the city I teach in now]. I could possible speak to integration of read alouds with lessons as I have tried to do far more of that this year because my kids lack so much background knowledge. I could possible speak to issues with ELL. But I am not really sure specifically. I am in the midst of teaching the weather unit now and I have had to do MAJOR modification with my kids. (email 5/4/06)

This initial thinking of Maggie's ended up being reflected in much of the work she did throughout this project, as described next. The final versions of the images Maggie wrote about this theme are provided in Appendix B.

Maggie's Pedagogical Design Capacity: Attending to Students at Every Turn

How does Maggie construct her narratives and what does it tell us about her pedagogical design capacity? To explore Maggie's pedagogical design capacity, we need to consider the modifications she made to the lessons as well as the reasons behind her decisions.

Maggie's Curricular Adaptations

Maggie made changes to the CASES curriculum materials that reflected her priorities and her understanding of her students. These changes included adding new investigations or hands-on experiences, adding texts, changing the approaches for data gathering and data recording, and adding and removing scaffolding.

For example, for the Weather Observations lesson, Maggie reduced the number of types of observations students made (e.g., eliminating humidity) and changed the observations to be qualitative rather than quantitative. She said she made these changes to the data gathering in part to help her students become better observers—to notice what the world around them is like (int. 5/11/06 lines 507-508; int. 5/17/06 lines 798-800; online disc. 5/13/06, "Lesson 1: Establishing Daily Weather Observations"). For example, Maggie said,

> [A] lot of the changes I make take away the numbers and are focused more on them looking at things and watching things and trying to be aware of things. (int. 5/17/06 lines 798-800)

In discussing her changes to this lesson, Maggie commented on the importance of understanding her students. For example, she discussed changing a worksheet according to her understanding of her students:

> I think that my modification here went mainly to the format of the observations that they were doing and the information that they were collecting and I think that that has a lot to do with knowing your kids and their background knowledge. … Um, because looking at the sheet that was up there before I noticed that some of the, the information they were asking the kids to collect just wouldn't mean a whole lot … to my students. Either because they haven't had other units taught to them on weather or because they're just, they don't even look at where they're walking so, you know like for them to think about the humidity is going to be like [making the students confused]. (int. 5/17/06 lines 219-229)

For the Wind lesson, Maggie added an unusual read-aloud text. The book included descriptions of small investigations students could do themselves, and Maggie stopped the reading each time they reached an investigation, and engaged the class in the investigation. In this way she incorporated informational text into the lesson, but also additional hands-on experiences. She said she made this change to build her students' background knowledge (int. 5/17/06 lines 242-243; online disc. 5/14/06, "Lesson 2: Wind"). For example, Maggie said:

> I focused mainly on incorporating that read aloud by Vicki Cobb and the little experiment, like the little activities that the kids could do to really start building that, that foundation of knowledge about air and wind um, because they really had nothing [correct]. (int. 5/17/06 lines 242-243)

She cited specific alternative ideas that her students held—for example, that trees make wind (int. 5/17/06 line 1013-1021) or that wind is alive (int. 5/17/06 line 1025-1026). She thought the information in the text helped students reconsider those ideas. However, she also

expressed concern about whether, by adding text to build that background knowledge, was she "giving them too much" (int. 5/17/06 lines 1038, see also 1037-1049, 1097). Maggie said:

> I sometimes worry about giving them too much so that the inquiry part is kind of gone where, especially with that Wind lesson I almost got to point, I was so worried about them not getting it when we did the experiment, or coming up with all these ideas like um … At some point and I sometimes get, I, I like walk this line between wanting them to have as much as knowledge as they need to understand it but not wanting to give it away. (int. 5/17/06 lines 1037-1049)

She wanted to maintain an inquiry orientation and was not certain that her addition of text to build background knowledge was consistent with that orientation—despite this particular text's inclusion of numerous investigations. Maggie decided in the end, though, that the addition of the text and the investigations was helpful for her students.

Similarly, for the Seasons lesson, Maggie added multiple additional hands-on experiences in addition to the one suggested in the CASES lesson plan, to help her students develop a better understanding of the phenomenon. These additional hands-on experiences included using Styrofoam balls (int. 5/17/06 lines 588-606), globes (int. 5/17/06 lines 607-615), and hands (int. 5/17/06 lines 628-661) to represent the earth. Maggie drew on specific aspects of her PCK and her knowledge of students in considering these changes, and in explicating the value she saw for students' learning, Maggie stated:

> Giving them more experiences to really make it concrete and so that they can, I always think about having these like hooks to hang the information on. (int. 5/17/06 lines 671-673)

For the lesson modeling the formation of clouds, Maggie provided an additional support for students' observations. She told us that in previous years, only one or two small groups saw the desired change; she wanted, again, to support her students this year in engaging in more effective observation (int. 5/17/06 lines 500-504; online disc. 5/16/06, "Lesson 4: Cloud Formation"). Maggie talked about how she would support more intensive observation in part through changing the structure provided for students' observations:

> [I focused on] the use of including a graphic organizer or some kind of organizer to have them really um … and it's not like a worksheet, but its like um, almost like a, like an experiment data collection kind of thing where, you know in that lesson they're supposed to be observing their, their cloud in the cup on the raised earth every five minutes, you know. (int. 5/17/06 lines 500-504)

Here, she increased the amount of observation, changed the type of observations, and provided scaffolding—all toward the end of making the experiment more successful and thus more likely to contribute to students' learning. Maggie discussed benefits of these changes to her students and to herself:

> I almost feel like they feel like they're more, like science students when they get to write stuff down and keep track of what's happening. And I also think it's great for them, with their observations skills, because I can kind of assess as we go along who knows how to make a good observation and who's still talking about what they think is happening even though it's not what they see. (int. 5/17/06 lines 523-529)

The changes Maggie described throughout the unit were in keeping with the intentions of the curriculum developers, in that they continued to support students in engaging in inquiry-

oriented science and simply provided additional experiences and/or support for their investigation and sense-making. In addition, she often pointed out tradeoffs in the decisions she made. For example, Maggie acknowledged that by removing humidity from the set of weather observations students make during the unit, she postponed their encountering ideas about humidity until the portion of the unit focused on the water cycle—perhaps accounting for some of their difficulties in understanding concepts related to the water cycle (int. 5/17/06 lines 865-879). In sum, Maggie's curricular adaptations reflected a sophisticated interplay between the written lesson plans and her understanding of her students.

The Basis for Maggie's Curricular Adaptations

On what knowledge, experiences, and resources did Maggie draw as she made decisions about changes to make? Maggie drew extensively on her knowledge of and experiences with her current and previous students, as well as her PCK with regard to their specific ideas and her knowledge of their school context—all of which are related to the general notion of knowing her students. Maggie also used her previous teaching and learning experiences and CASES and other resources to guide her decision-making. We discuss her reliance on her knowledge of students (and related aspects of her knowledge) first.

In our initial interview with Maggie (int. 5/11/06 lines 508-540, 565-577), she anticipated that she would be able to compare her third graders this year in the urban district with the fourth graders she taught in a private, suburban school a previous year. When asked what, specifically, accounted for the differences between the two groups of students, Maggie listed numerous factors. Maggie said:

> And I don't know if that's because of the age or if it's because, you know my kids don't have computer access so they're going to have to do weather observations based on the news and based on what they can see outside. … Or it could so be that I would, I didn't think that my kids in [the suburb] got a ton out of doing the observations by just pulling up a webpage, you know so I don't know. But there definitely has been modifications that I've done with, not only like the structure of the worksheets that I give them to guide their thinking, but also what I have to do to get them ready or, for the thinking that they're going to be doing, you know with the science and I think that that, like I said, it could either be the age or it could just be because um, because science isn't stressed until you're in fourth grade in [my city] so a lot of these kids didn't, you know when I asked them where they thought wind came from a majority of them said God, you know (laugh). It's like, okay. [laughter] … They had a lot of good suggestions, you know like some of the kids thought it came from God or a man blowing up in the clouds … Everything from that to, you know at the other end the earth's rotation and the earth spinning causes the wind, the air to move which causes wind. … So, so when you have a range of thought in your classroom like that, just like when you have, it's almost like their reading levels, I have everything down from kids you are now reading at a first grade level all the way up to kids who are reading in high school, you know high school in comprehension level so… (int. 5/11/06 lines 508-540)

Here as well as elsewhere in the data (e.g., int. 5/17/06 line 843, lines 857-861), Maggie acknowledged the difference in age and general setting (i.e., urban versus suburban), but also noted additional factors: science is not stressed until fourth grade in her school, many of her current students are English language learners, and her students exhibit a very wide range of reading levels. In multiple interviews, she talked about how her students' family context affects what scientific data she decides to have them collect; she said, for example, that since most of her students do not have computers or internet access at home, she cannot expect them to collect

daily temperature data using computers, as she used to in the suburban setting (int. 5/11/06 lines 508-511; int. 5/17/06 lines 906-907).

Maggie also emphasized her learning goals for her students, related to both content and inquiry goals. For example, she wanted her students to develop observation skills (e.g., int. 5/11/06 lines 507-511, lines 639-641) and understand the difference between an observation and a hypothesis (e.g., int. 5/17/06 line 534). She stressed conceptual understanding repeatedly, and saw the connection between the inquiry goals she had for students and the development of their conceptual understanding. For example, she noted that her students had not been asked "why" in previous grades. But, Maggie said, her class focused extensively on saying "why" and providing evidence for one's thinking (int. 5/17/06 lines 931-943). Maggie said:

> Like a lot of my kids, it was amazing to me, how many of them … [I]t's like when you say to me you need, I'd like you to be able to tell me what you do but also why you do it. … Like my kids have, know that about me that they've gotten to the point where they're like and do we need to write why? I'm like you do even need to ask? … You know of course you have to write why. You do it in math, you do it in reading. We do it all over. They have to provide evidence for what they're saying. (int. 5/17/06 lines 931-943)

Although the unit Maggie was using incorporated a fairly even focus across the inquiry practices, Maggie herself emphasized (among other things) the role of using evidence to support claims.

In sum, Maggie drew on her knowledge of the students' family contexts and previous school experiences to inform her thinking about what learning goals were appropriate and what kinds of support she needed to provide.

Maggie also had a rich set of teaching experiences and she drew on these extensively in planning and enacting her instruction. For example, she talked about having developed an integrated weather unit for one of her masters in special education courses (int. 5/11/06 lines 1129-1135). More significantly, she regularly drew on her previous teaching experiences, including at other schools. For example, when describing the changes she would make to the CASES Seasons lesson, she discussed having taught a lesson on seasons for her demonstration lesson for her masters degree as well as during her student teaching 7 years earlier (int. 5/17/06 lines 583-590).

Finally, Maggie also drew on a wealth of additional resources from within and outside the CASES curriculum materials. Maggie used the CASES worksheets and lessons as sources of ideas, but typically modified them based on her knowledge of her students as discussed above. She also used another feature in CASES, which lists additional science lessons that would further support the development of students' ideas (int. 5/11/06 lines 645-653). About this feature, Maggie said:

> But also, you know where it says at the bottom [of the unit introduction page on CASES], "lessons you might also want to develop", which has been hugely helpful, I don't know if that's a new thing or, I don't remember seeing that, I don't, maybe I just didn't really pay attention to it before but. So like the first week it's like lessons that you might want to develop making a barometer, measuring in Celsius and Fahrenheit. Learning to read a weather map, types of clouds and the weather they bring. Like for me because I do four days of science and, or I'm supposed to do four days of science, I try to do four days of science on the weeks that I'm doing science, I try to bring in as many of those lessons as I can. (int. 5/11/06 lines 645-653)

Maggie also discussed her previous use of the CASES images of inquiry, describing how she incorporated ideas from the images into her own teaching of the lesson (int. 5/11/06 lines 431-445; int. 5/17/06 lines 1055-1058; int. 6/22/06 lines 497-539). Although Maggie did not appear to use the existing images of inquiry extensively, when she did read them, she found them useful.

Maggie also talked about her use of books by the author Vicki Cobb. She described these books as potentially too young for her students, but made the decision to use them because of the books' incorporation of science investigations alongside easy-to-interpret informational text (int. 5/17/06 lines 240-258). Maggie said:

> I thought it was great that it was like in a book because the kids get really excited about going to the library and being able to, and she has entire series and I think they're geared more for younger kids but I feel like maybe younger suburban kids … who, you know will have an opportunity to do like do all these great activities and so literally we just went through the book and every time we would come to an activity we'd stop and do it real quick. (int. 5/17/06 lines 247-256)

Maggie discussed these and other books as a way to build her students' background knowledge, as discussed above.

In sum, the changes Maggie made to curriculum materials demonstrate an effective understanding of her students and of inquiry-oriented science teaching. Furthermore, Maggie drew on an array of knowledge, experiences, and resources to inform her decision-making. This body of knowledge, experiences, and resources contributes to her pedagogical design capacity.

Maggie's Development as a Professional: Increasing Awareness

Recall that our second research question asks, How does the construction of narratives grounded in curriculum materials contribute to teacher development? To address this research question, we examined how Maggie talked about the benefits she initially expected to get out of her participation in this professional development opportunity, and how this compared to what she perceived as benefits at the end of the process.

Maggie initially described two benefits of writing narratives about her science teaching in this way:

> So any time where I can sit down and like think about what I've done in and, and kind of reflect on it is good for me but also knowing that I've been doing this for six years maybe I have some knowledge. (int. 5/11/06 lines 379-381)

Here Maggie identified two important benefits: reflection on her own teaching (thus helping herself) and allowing others access to her knowledge and expertise (thus helping others).

She also saw a benefit to working with another teacher (i.e., Catie), though she described this benefit mainly in terms of giving her a deadline by which she would have to do the work. Maggie also talked about the fact that her participation in the CASES project was the only professional development opportunity she had ever had in regard to her science teaching, so she did not usually have the opportunity to reflect explicitly on her science teaching (int. 5/11/06 lines 335-336). She said:

> I've learned a lot about reflecting on my teaching in the past few years which has been um, I think like throughout every area that I've taught that I've done professional development in which, you know CASES for me is pretty much the only science professional development that I've done since I've started teaching. (int. 5/11/06 lines 333-336)

Although Maggie seemed enthusiastic about participating in the project and identified some potential benefits, her discussion of expected benefits at the start of the project seemed largely *pro forma*.

After finishing the process, what benefits did Maggie see to participating? Maggie noted two benefits. First, in our final interview with Maggie, she said that she felt better about her science teaching after having engaged in the process of writing narratives about her teaching. She said that she realized that she really knew her students and that they gained a lot of knowledge during the weather unit. She attributed this outcome to her participation in writing the narratives, because, she said, she was paying so much attention to her science teaching and how her students understood the ideas (int. 6/22/06 lines 650-678).

Second, and more centrally, she recognized an increased awareness of the role of curricular adaptation or modification in her professional role. Maggie wrote:

> I think one of the most eye-opening things for me was the fact that I DO modify almost every plan that is handed to me based on the needs of my students. I never had to fabricate doing anything, I didn't even have to look really hard. As beneficial as these modification images might be for a new teacher, they were also beneficial for me trying to reflect on my science teaching. (journal 6/13/06)

In this journal entry and our follow-up interview, Maggie seemed genuinely surprised at the extent to which she modified lesson plans—usually without even noticing that she was doing so. Maggie talked in our final interview about how central this aspect of modifying curriculum materials had become in thinking about herself as a teacher. She said that when she first started teaching, she did not know she was allowed to or supposed to modify curriculum materials; she saw her job as to enact the materials as written. Now, after teaching for several years, she said she saw this modification as absolutely central to teaching. She connected this modification directly to her knowledge of students; the modifications she made were very much made with her students in mind. About the centrality of making modifications to curriculum materials, Maggie said:

> I think that, that it, I think it's true in almost everything I do. Um, because one of the best things about teaching, especially when you're, um, when you're a self-contained teacher is you really get to know your kids. And it might take a month or two to really get to know them but by the end of the year I could tell you the inside and outside of every one of my students. … I can even think in math it, it's a small modification but my children are, you know where in the, in the plan book for Everyday Math it says, this is something you should do individually, I usually guide my kids using overheads through everything. I mean I let them work on their own but then I'll bring them back. But it's never said that you have to have overheads for everything you do, and I do. … I'm inventing everything based on the needs of my kids. (int. 6/22/06 lines 554-582)

Consistently, Maggie connected the modification she does with knowing her students. For example, when asked what she would hope preservice and beginning teachers might get out

of reading the images she wrote, Maggie talked about how she hoped that new teachers would learn that it is acceptable and even encouraged to change lesson plans based on an understanding of one's own students, as well as gaining specific ideas about how to do so. Maggie said:

> I think that I would want them to read the images as they're doing planning for the unit to see, one, the overall idea of modification and that, you know it … it was so long ago that I was a pre-service teacher or a first year teacher that I don't remember, I mean, like I've said before modification comes so easily to me … You forget what it's like to be the newbie, like to be the, the new teacher on the block and trying to get a handle on all of this. So I think just the theme of modification and knowing that it's okay to do that and you really need to know your students. You know like even in this math meeting, these math trainings that I've been doing, the teachers have been saying, you know but what about this with my kids? And it's really comforting to be able to say, you know your students better than anyone. This is like where the art part of teaching comes in … and when you know your kids you don't have to go Step A. This is not a script that you're supposed to follow. You need to take the good and fix what is not going to work out so well for your kids. So just knowing that whole idea I think is really helpful but then also seeing some examples of, not just saying, it's okay to modify, period … but it's okay to modify and here's the way that I've done it. And you might choose to do it a different way but here's one way that might work for you, so. I would hope that, like specific examples would help with that too because they might look at the examples that I've done and either (a) do that exactly, which is what, you know I've done with some of the images that are up there, or (b) it might spur some other kind of thinking in them of something they might do that might work for their kids. … [Y]ou know it goes both ways. It's not just, ah, you should read this if you are working with inner city children and they don't have a lot of science background. (int. 6/22/06 lines 497-539)

In other words, she hoped new teachers might learn the lesson she learned through her first few years of teaching and became more aware of the importance of curricular adaptation as a result of writing narratives about her teaching. Note Maggie's statement that she wanted new teachers to recognize the importance of modification and to know that "it's okay to do that and you really need to know your students." Maggie connected these two ideas of modification and knowledge of students explicitly here and consistently connected these ideas both implicitly and explicitly throughout the data.

In our final interview with Maggie, we see evidence of how her identity was integrated with this idea of curricular modification. Maggie engaged in a spontaneous and passionate discussion of teaching as a profession, not just a job. She saw the issue of modifying curriculum materials based on her students' ideas and needs as being very connected to her ideas about what it means to be a professional. For example, in a part of this discussion, Maggie said:

> [I]t always makes me think of that whole idea that teaching is really, that not everyone can do it. You know what I mean? There are people that, like everyone can go through this education program but it's when you get into the classroom and you really start to get into your career and get it going. Like I don't think that the modification that I do now I necessarily would have done from day one and it's the more experienced you get, that I feel like, the easier it comes and the more subtle it becomes. But that's the whole reason that, um, scripted curriculum is such a bad idea I feel like because it gives you no room to accommodate for what you need to accommodate for in your classroom. And there are a lot of pushes towards, you know this idea that if we want everything to be consistent and we want to have the same standards that we all have to be teaching the same thing the same way on the same day so that it's consistent for the children. And I really, I don't know, it just, it scares me to think about that because you could take anyone off the street and give them a script but you need to have like an educated person in education to realize the need for their kids sometimes. And I feel, I don't know, like it's become more clear to me when teachers have come, especially working with other teachers the way I've been doing even in the past couple of days [leading a math professional development workshop], how everyone approaches

> things differently and yet it works for them. And I never would have thought of it but, um, but you just, it's, it's that whole idea that teaching is not just this job. It's a profession, you know what I mean? … There are a lot of people in my school who, they've jumped through all the hoops but they're, they're not like, I don't, they're just not able to see things as easily…. (int. 6/22/06 lines 833-862)

Thus, while Maggie previously engaged in the analysis and modification of curriculum materials with regard to her students, she became more *aware* of this as a central practice of her teaching as a result of the process of writing the narratives. In addition, Maggie experienced an improvement in her self-efficacy as a science teacher that she attributed directly to her participation in the professional development experience of writing the narratives.

Catie's Theme: Organization

Catie chose to focus her narrative images of inquiry on the theme of "how to help kids get organized" (email 5/9/06). She saw this focus as a way to further explore and apply ideas she was exploring as a part of her masters thesis (for a masters degree in science education at a nearby institution), including foldables, science notebooks, and more typical worksheets. Catie connected the idea of foldables to work done by an author named Dinah Zikes (int. 5/11/06 lines 804-827). Catie also attributed the idea of science notebooks to a specific book (*Science Notebooks* by Brian Campbell) (email 5/9/06; int.5/11/06 line 791). Catie wrote:

> One of the things I want to incorporate in my theme is the idea that there may be different ways to organize different kids and different projects and how do you do that within one unit. In "Science Notebooks" they discussed the idea of showing kids a few methods of recording in general and then letting them decide what was important to write. I am interested in this from several stand points, some being creativity, how to assess and how organizational styles function even if they aren't the teacher's method of choice. (email 5/9/06)

In our initial interview with Catie, she discussed both recording and organizing. She differentiated the two as follows:

> [T]o me like recording is, you know they're copying something down into a designated spot. It maybe is something that they've created, like a chart or something that they've created or it could be you know like a worksheet that they're recording information into but it seems to me that when you're recording something you've already got the organizational system in place. Whereas learning an organizational skill in general is something that you have to have in order to record information, because if it's not organized at least in a way that you understand it, you know if no one else understands it that's one thing as long as you understand it, if you don't have that and you go back and you can't even understand what you've written then it's all lost, do you know what I mean? (int. 5/11/06 lines 1020-1029)

Catie's images ended up focusing on various aspects of recording, and organizing more generally, with a predominant emphasis on recording data and other information. The final versions of the images Catie wrote about this theme are provided in Appendix C.

Catie's Pedagogical Design Capacity: Meeting (Different) Learning Goals

How does Catie construct her narratives describing her curricular adaptations around the theme of organization? How does this inform our understanding of her pedagogical design capacity?

Catie's Curricular Adaptations

The CASES unit with which Catie was working included a very prominent focus on scientific explanations—here instantiated as supporting claims with evidence. The teacher materials provided extensive support for the teacher in thinking about explanation and in helping children construct explanations. Likewise, the student materials provided extensive support to help children make claims and support those claims with evidence. Catie had used the materials, including the student materials, the previous year (see Beyer & Davis, in review).

Catie's main curricular adaptations to the CASES curriculum materials have to do with how data are recorded and how she supported that recording of data. To summarize, she provided additional scaffolding through things she said to her students, gave students some freedom in determining what data to record, and limited her use of CASES student worksheets—which provided specific supports for scientific explanation—instead choosing other methods for organizing students' ideas.

A central priority for Catie was making accurate observations and descriptions of scientific phenomena. Consistently, Catie emphasized how important she thought careful recording of observations was. She regularly made statements like:

> [I]n this particular experiment [for the Finding Seeds lesson] that we just did they were recording pictures mostly and, you know and that's another really big skill that I want them to have because I, you know from the beginning of the year my big thing is it has to look like what you saw in order for someone who is never going to see that object to know what it is from your picture. (int. 5/11/06 lines 1082-1086)

Later in the same interview, Catie continued on this theme, again regarding the Finding Seeds lesson:

> I told them today, I don't want to see just a bunch of circles because not all these seeds look the same. You know really put some detail into them, they're not all the same shape, they're not all the same size, they're not all the same color. (int. 5/11/06 lines 1874-1877)

Throughout our conversations with Catie, both in the interviews for this study and throughout our longitudinal study more generally, Catie emphasized this importance of using accurate drawings to communicate "to someone who wasn't there."

Although she did not refer to it as providing additional scaffolding, Catie made frequent references to statements she made in class that provided teacher scaffolding to the children, typically around the task of recording observations or data, often using personal examples or analogies to help them see the importance of accuracy and labels (e.g., int. 5/15/06 lines 2.281-296, 2.302-324, 2.371-380). (The interview for 5/15/06 was interrupted briefly, and thus lines numbers from this interview are referred to as 1.xxx or 2.xxx.)

Catie also emphasized the importance of letting her students decide what data they wanted to record, and of providing guidance to help them make decisions. For example, in the online discussion toward the beginning of the process, Catie wrote:

> I think that I would use their science notebooks and let them decide a "best way" to write down the information. I would suggest a chart with pictures of the seeds in one column, and water, wind and sticking

> in each column and have them write in the appropriate column what the seed did in order for them to predict that this is the method of travel. I think that they could do this. (online discussion posted 5/14/06, "Lesson 3: Looking at How Seeds Move")

Later, Catie clarified that she does not intend for this to be a free-for-all, but she does want them to think about what will allow them to communicate their ideas clearly to others (online discussion posted 5/23/06, "Lesson 3: Looking at How Seeds Move").

Toward the goal of structuring students' recording of data, Catie made curricular adaptations related to the amount of scaffolding and changing the worksheets she used—the mechanisms she used for structuring students' data recording. For example, Catie made changes to incorporate a "foldable" into one of the lessons, rather than using the existing CASES supports for recording data. Catie had learned about the idea of foldables in her masters classes, and found the idea intriguing—in fact, she was exploring the idea in her masters thesis. Catie described how she used a foldable in the lesson on Finding Seeds:

> I had them make one, it's called a six panel and it's kind of the same idea of the, you know the little flaps that they drew the six fruits that their group was working on, on the outside with the label, and then on the inside flap was a picture of the seed and, you know a little description about it. But that, it's just one way of helping the kids to organize their information that's not like writing out a lab report or something like that. … I'm also finding that it's working on their fine motor skills. (int. 5/11/06 lines 879-885)

Later in the same interview, Catie said:

> [A]s far as the Finding Seeds in fruit [lesson] I did it pretty, I like organized it pretty much the same way [as in the CASES lesson plan] but the recording was different. I didn't have them use the pages from the notebook. I thought about it but then I was like, well, I'm going to try this foldable thing and see how that goes instead. (int. 5/11/06 lines 1860-1863)

Changes like this moved her away from using the student worksheets provided in the CASES materials, which provided scaffolding focused on not just the recording of observations, but the use of those observations as evidence for claims. These changes moved Catie toward incorporating a collection of other "organizational" approaches—foldables, new data recording sheets, and the like (e.g., int. 5/11/06 lines 922-932, 941-962, 1857-1863; int. 5/15/06 lines 1.465-490, 1.519-523; int. 7/18/06 lines 202-214). Catie discussed her reasoning for not using the CASES student materials in terms of how lengthy the materials were—a legitimate concern:

> [E]specially since this um, unit has so much hands on stuff in it that it, that organization is such a key thing. Because those notebooks that … you guys [on the CASES team] had made last year were wonderful but they are really long and the kids were getting like sloppy towards the end because it was so many pages, I think it was like sixty pages …or something. And so they were getting, you know kind of annoyed or, you know bored with it or whatever it was and so I thought, okay, well how, how can I use like the ideas because I like all the worksheets … and like, you know all the little activities, so I think how can I change this so it doesn't require so much writing or so much, you know like drawing and all so that they don't get bored. (int. 5/11/06 lines 941-962)

Catie reiterated these concerns later, as well, stating that students got "overwhelmed" by the CASES student notebooks (int. 5/15/06 lines 1.519-523).

In another instance of a change away from the CASES materials, Catie incorporated a new data table for recording observations of plants over time, in the Do Plants Need Sunlight? lesson. The boxes in which students' observations were to be drawn were quite a bit smaller than the ones provided in the CASES materials. Catie discussed some pros and cons of this approach, noting, for example, that students would be more easily able to make the "visual comparison" by including more observations on a single page (int. 5/15/06 lines 2.422-438)—a real benefit of this change. She did not note, however, how this change might work against her goal of having her young students with limited fine motor skills make accurate drawings of their observations (online discussion, 5/14/06, "Lesson 5: Do Plants Need Sunlight?"); in such small boxes, it might be difficult for young children to incorporate the detail she said she valued.

One main difference between Maggie and Catie is that Catie rarely made changes in terms of adding investigations, whereas Maggie made this type of change very frequently. Two reasons may explain this distinct difference between the two teachers. First, Catie's theme did not lend itself to discussing the addition of investigations, where as Maggie's theme did. Second, Catie's classroom context worked against adding investigations and Catie did not, to our knowledge, add any investigations to the plants unit (although she did replace one CASES lesson with a different lesson). With 30 second-graders, Catie faced logistical challenges in engaging students in investigations or experiments.

Instead, Catie's curricular adaptations fit her own theme, related to organization in science, and specifically focused mainly on ways of structuring differently the students' recording of data. Unlike Maggie's changes, though, Catie's changes were often at odds with the intentions of the CASES curriculum developers. Specifically, the CASES student materials were intended to support students in recording accurate observation of physical phenomena and using those observations as evidence in scientific explanations. By removing these materials and replacing them with foldables and other data recording structures, Catie typically maintained a focus on data collection and making careful observations (and addressed other goals as well) but removed the connection between claims and evidence that was supported by the CASES materials. At times, the changes may have also worked against the goal of recording accurate observations. As we show in the following section, this move probably had to do with a fundamental mismatch between Catie's learning goals for her students and those embodied in the CASES materials.

The Basis for Catie's Curricular Adaptations

Catie mainly based her curricular adaptations on statements about learning goals. She did so more than Maggie did. To summarize, Catie clearly held high expectations for her students and her goals for them were wide ranging and increased over the school year. However, some of these goals were in tension with one another. Catie also based her curricular adaptations on her knowledge of students, as did Maggie; learning goals, however, seemed to be the central driving force for Catie, as we describe here.

Throughout these interviews and throughout our longitudinal data focused on Catie, as well, we see evidence that Catie held high expectations for her students (e.g., int. 5/11/06 lines 1070-1086; int. 5/15/06 lines 1.301-318, 1.608-625, 2.332-341, 2.1054-1064, 2.1068-1072) and that she values a wide range of goals (e.g., int. 5/11/06 lines 1070-1078; int. 5/15/06 2.332-341,

lines 2.1054-1064). She regularly made comments about what she expected children to be able to do, despite their young age. Indeed, Catie's expectations for her students increase throughout the school year. While discussing her thinking about the Grouping Seeds lesson, in which Catie wants her students to be able to classify seeds in multiple ways, Catie said:

> [A]t the beginning of the year I try and do um, just some like lessons on just skill building, like science skill building, because in first grade they don't do any, any experimentation really at all and kindergarten there is like barely any science in general, as you know, reading a few books here and there. So I, you know I try and focus on that kind of thing at the beginning of the year and we do this little lesson with buttons where they have to kind of like sort of them out into different kind of characteristics and, you know I'm happy with them doing size and color, you know at the beginning of the year and, you know we do some other things, you know similar to that where it's a little more simplistic but like towards the end of the year I expect them to be, you know sorting them in other ways because size and color for them is something simple and it's, it's really not challenging and so they're done in like two minutes, you know. It's not something that gets them thinking. … [W]hy should I bother doing this if it's not going to promote, you know higher level of thinking than what they already know? (int. 5/15/06 lines 1.608-625)

Later in the same interview, Catie connected this skill of classifying to scientific practice, mentioning that scientists classify dinosaur bones that they find and scientists classify animals based on characteristics; Catie said, "scientists do that [classifying] all the time… and it's not just based on size and color" (int. 5/15/06 lines 1.659-665).

On the other hand, Catie's description of what her students accomplished in the previous year through participation in the CASES plants unit remained focused on learning content and on some general skills. Catie and the interviewer had this exchange in the initial interview:

> I: … So would you say, did you feel like last year did the kids learn what you wanted them to learn?
>
> C: Oh yeah. Yeah, I, I really thought that they, you know like, well not only be, you know information about plants and, and seeds and all that but I think they also learned a lot about, you know how to interact with each other in an activity sense and a hands on sense. How to think about things when the answers aren't given to you, you know that kind of stuff, that's important, um, for them to learn how to do. (int. 5/11/06 lines 1825-1832)

Although Catie mentions many important outcomes of her previous use of the plants unit, she does not note the materials' emphasis on providing evidence for claims. The closest she comes is her mention of "how to think about things when the answers aren't given to you" which seems more akin to the critical thinking skills Catie holds as crucial.

In sum, Catie's learning goals appeared to be a mix of general developmental goals for lower elementary children (e.g., the improvement of fine motor skills), general learning skills valued by many teachers (e.g., creativity, critical thinking, and collaboration), knowledge and skills in other subjects (e.g., writing sentences), and science-specific knowledge and skills related to content and science processes (e.g., learning the proper terminology for human body parts, learning to classify along dimensions other than color and size). These are all, of course, important learning goals for lower elementary children, and Catie clearly values her students' progress in these arenas.

These interviews also reveal, however, a tension that Catie saw between aspects of those high expectations. Specifically, Catie wanted her students to learn to "be organized" but she also wanted them to develop creativity; she struggled between providing structure for her students and expecting them to "use their creativity" to find solutions to data-recording problems. For example, in discussing her reasons for having children decide what data to record for the How Seeds Move lesson, Catie drew on a book she read about science notebooks, as mentioned above:

> *Science Notebooks* um, that I read, and that's a publication by NSTA, talks about how it should be something that the kids do um, you know record information on their own that they think is important, not necessarily for you to grade um, but you promote um, good organizational skills and, and um, them writing down the important information by making them use what's in their notebook on another project. … Like they have to use it in order to apply it. So they know, oh my gosh, you know next time I need to write down more, I need to include … (int. 5/11/06 lines 903-914)

Here and elsewhere, Catie seemed to buy into the notion of allowing children to decide what is important to record. Yet Catie saw the freedom recommended (in her eyes) by the book on science notebooks as potentially working against students' development of ways of representing their ideas that are understandable to others (e.g., int. 5/11/06 lines 1213-1217; int. 5/15/06 lines 1.393-407, lines 1.637-641). In the end, Catie decided that a mix of approaches was most valuable for her in meeting her many learning goals. Catie said:

> C: … I mean they will at, at some point in time come up, you know come across the situation where they are going to have to put together some sort of worksheet for themselves or some sort of organizational method and they're going to have to have, you know a wealth of knowledge or some sort of, you know previous knowledge about organizing themselves. So, you know that's, and that's part of the reason I was thinking like, you know organizing has got to be like a mixture of, you know worksheets and them doing things on their own because they, I mean they've got to try it out but it shouldn't be always that way, you know.
>
> I: Always what way? Always …
>
> C: Well it, you know they've got to try out, like doing their own, like write down what's important or write it in their organization in a way that is important to you. You know it, it's got to be partially that but you've also got to have structured work, you know structured, ah, worksheets where they kind of fill in the information. … Because they, they don't, they don't have enough experience with, you know science to begin with … so they need to do … a mixture …. (int. 5/15/06 lines 2.699-721)

In her narratives, Catie in fact ended up suggesting a mix of organizational approaches in hopes of achieving her varied learning goals.

In addition to basing her curricular adaptations on her learning goals, Catie also based her changes on her knowledge of students. This focus, while somewhat prominent in the data, was less prominent for Catie than was her focus on learning goals, and it was also far less prominent and less nuanced than it was for Maggie.

Catie seemed to hold a general belief that every child is different (e.g., int. 5/11/06 lines 1118-1140, 1255-1292). In one instance, Catie was somewhat specific, discussing students with special needs (int. 5/15/06 lines 1.322-342). Much more typically, Catie said, essentially, that different children have different strengths.

On the other hand, Catie also generalized about her students. She stated several times that many of her decisions were made on the basis that she knew that her students were young and, at times, sloppy, bored, or overwhelmed (e.g., int. 5/11/06 lines 943-962; int. 5/15/06 lines 1.521-523, lines 1.654-659, lines 2.611-614, lines 2.955-965, lines 2.1063-1064). Catie made similar characterizations of her second-grade students in a previous study (Beyer & Davis, in review). In discussing her decision not to use the CASES student materials for the plants unit, Catie referred numerous times to her experience with the materials the previous year, as described above (int. 5/11/06 lines 943-962; int. 5/15/06 lines 1.521-523). In discussing how successful students would be with generating their own worksheets (an idea Catie had for changing the Investigating Plants lesson), Catie said:

> [S]ome of the kids would be really good about making up, you know worksheets for me but some of them, you know would, aren't, are just not into doing kind of thing. So (sigh) they would get sloppy and that so I'm not sure if it would work or not, right. (int. 5/15/06, lines 2.611-614)

Here Catie notes both the issue of sloppiness and the additional issue of what the kids are "into" in terms of preferences. Although she seemed to point to the children's youth as a reason for the sloppiness she often perceived, at the same time she did not use this to dismiss them from her high expectations. For example, as noted above, despite their youth Catie expected them to learn complicated science ideas and vocabulary (int. 5/15/06 lines 2.1063-1064). She saw her students as lacking prior knowledge and experiences, so she wanted to help them build that repertoire (e.g., int. 5/11/06 lines 1326-1329, lines 1374-1385).

Catie made general statements, especially in the last interview, about teachers needing to adjust to their own group students (e.g., int. 7/18/06 lines 222-226, lines 409-419, lines 473-477). For example, she said:

> Because it's, I think that's a, that's a huge, a huge problem is, is people just take everything [in curriculum materials] for, you know for, you know verbatim, like it has to be this way because it's been printed, you know like … someone thought this was important, you know like it has to be kept this way or doesn't so. I, you know that's, I guess being flexible, being creative changing things when you think they're needed, needing to be changed. Even, even when you know that they came from a reliable source it might not be something that's good for your group. (int. 7/18/06 lines 409-419)

And, later in the same interview, she said:

> I think they have to consider their group of kids um, you know some lessons might be really, like sound really fun on paper um, like to substitute or whatever, but you might not have a group of kids that is, you know intellectually ready for it or responsible to follow directions, or you might have too big of a group, you know in order to do something like that. (int. 7/18/06 lines 473-477)

In general, although Catie did draw on her knowledge of students in making curricular adaptations, these and other examples indicate that she considered her students in far less nuanced ways than did Maggie. Catie also drew far less than Maggie did on her own previous teaching experiences, other than her previous experience teaching the CASES plants unit—a difference that is unsurprising given Maggie's more extensive and varied teaching experiences in similar grades. Far more important for Catie, it seemed, were her learning goals.

Catie's Development as a Professional: Changing Goals, Changing Lessons

Again, remember that our second research question asks how this process contributed to the teachers' development. Catie initially perceived benefits related to improving her own science teaching. She said she was "constantly changing my activities and looking for ideas" (int. 5/11/06 lines 659-661) and that she wanted "to become more familiar with the [CASES] plants unit" (int. 5/11/06 line 673). She noted a desire to reflect on her teaching and collaborate with another teacher (int. 5/11/06 lines 685-694), similar to what Maggie had stated. Also like Maggie, though, Catie's description of potential benefits was not very elaborated before participating in the process.

After participating in the process, Catie described three main benefits to herself: she thought she became a better writer, made a shift in her thinking about her learning goals for children, and learned that it is acceptable and even desirable to change existing curriculum materials (journal 7/7/06). We address the second and third of these perceived benefits.

First, Catie's perspective changed with regard to curriculum materials. In her journal, Catie wrote:

> My thinking about organization has changed somewhat because I have begun to feel more comfortable with changing things to accommodate my class. Every year is different and every lesson plan is just a baseline to start from. I used to think that the worksheets and procedures in the lesson plan were "the best." Now I know that they were "the best" for the particular situation they were invented in. But that they might not be for the situation they are being applied to. Knowing that it is okay to change things around to make them better for my class has been a really liberating experience as a teacher. (journal 7/7/06)

Unlike Maggie, Catie seemed to have not just gained awareness of a personal tendency toward modification of curriculum materials. She seemed to have shifted in a fundamental belief about how acceptable it is. In this sense, we see growth in Catie's pedagogical design capacity (Brown, in press; Brown & Edelson, 2003). Specifically, we see this as a shift in Catie's curricular role identity (Forbes & Davis, 2007).

Second, Catie perceived a shift in her thinking about learning goals by the end of her participation in this project. In her journal, Catie wrote:

> One of the things that really hit hard for me during the writing of these images was the idea that a science experiment or lesson doesn't always have to be about the science content and what the kids are learning about in regards to the subject at hand. It can be about teaching the kids how to experiment and how to learn and how to organize within the activity. I have always tried to find/create experiences to go along with what we are learning (weather, animals, plants, etc.). Now I find myself thinking that maybe I can go off and do something that isn't related to those topics but would teach the children a skill instead. (journal 7/7/06)

In the final interview, the interviewer asked her to expand on what she wrote. This exchange followed:

> C: Like you and I had a conversation earlier, and before I started writing about what I was going to do for each image, and you had said something, well, you know sometimes it's more about the kids practicing how to experiment rather than learning like some sort of content and I thought oh. You know a kind of like what's one of those light bulb moments for me, like you're right, you know it doesn't always have to be about them learning, you know something. It just maybe is learning how to do something … and then I, as

> I was looking over my units I thought well, you know I could really do this with all of them. Why does it have to be, you know something that's going to teach them that, you know something that, you know adaptation of animals make them able to live within a certain environment or whatever. Why can't it just be like them, you know practicing how would you, how would you test this, how would you, you know if you didn't know what an, what this adaptation was for. You know how would you test it, you know without coming to the right answer, that that's not the important part, the important part is like what you're experiment, what you're doing as opposed as to what you, what you get out of it. I guess that doesn't make a lot of sense.
>
> I: Interesting. No that's very interesting. So was that new then? …
>
> C: Uh huh. That was, like I mean I know when I was at [the university] you and, you and um, [my other science methods instructor] really, really stressed that but it wasn't something that I guess really clicked with me um, so much as I'd been teaching at [my school] maybe because I've been, you know bowled over by what their thoughts are about everything but … you know but I, it was kind of something that maybe I'd heard before but didn't believe … or maybe I'd heard before and didn't think much about or, or what have you, but when you said that it was like, oh, you know a big light bulb went off in my head, so you know that, that was something that I personally learned as a teacher just from doing the images, just from having the conversation with you. (int. 7/18/06 lines 562-601)

A bit later, Catie continued:

> I really this year had something that we were doing every single Thursday [when I had half of my class at a time]. Like something to do with science during that period, every single Thursday. But you know we get into units on like um, you know like the planets, for example, and I could not for the life of me think of a, of a lesson to go along with it so we'd always end up doing like some other random thing or maybe, you know something to do with an upcoming unit or a review from the last one but it wasn't it, it was just like, you know what, what can I teach these, like what are we going to do that's going to teach them about this? You know and then it dawned on me when we were talking I'm like oh, all those little, you know things that I was always worried about, I could of just done something on, you know observation skills or explaining, you know what you see or drawing a picture and labeling [unintelligible]. Like any of those science skills, you know without having to have gotten into the, gotten worried about oh, gee, you know, this isn't teaching them content. Because that was my concern constantly. (int. 7/18/06 lines 620-633)

In sum, Catie believed that the process of writing the images, and the conversations she had with us around her writing, helped her develop a more expansive set of learning goals for her students. In our longitudinal data and other analyses of Catie's perspective on teaching, we do see evidence of a focus on content, sometimes to the exclusion of inquiry-related goals (see Beyer & Davis, in review). Catie here seemed to see that her perspective was broadening, and it probably was; she even mentions "explaining" as a "science skill." However, even by the end of this project, we still see a mismatch between Catie's learning goals for her students and those espoused in the CASES curriculum materials. Catie seemed not to see a central connection between the careful observations she had her students make and the development of their understanding of content—a connection we would argue is supported by the construction of scientific explanations in the form of a claim supported by evidence. Despite her self-professed change with regard to her learning goals—and her sense that the change was supported by our conversations with her—we sense that we need to continue supporting Catie in developing an inquiry orientation consistent with science education reforms.

Discussion, Implications, and Conclusions

To summarize the results, Maggie's changes to the CASES curriculum materials were typically consistent with the CASES developers' intentions. Her curricular adaptations were

based mainly on her deep understanding of her students, although Maggie drew widely on other knowledge, experiences, and resources, as well. Maggie did not experience any wholesale change in her stance as a professional through participating in this process, but did become more aware of the extent to which she modifies existing curriculum materials to meet the needs of her students. She also felt more self-efficacious about her science teaching after participating in the intensive reflective experience. Catie's changes to the CASES curriculum materials were mostly consistent with her own learning goals, and were generally reasonable changes to make. Catie's changes, however, were not always consistent with the CASES developers' intentions. This lack of alignment may be due to a fundamental mismatch between the CASES developers' learning goals (which include an orientation toward evidence-based explanations and using inquiry practices to support deep understanding of science content) and Catie's own learning goals (which emphasize the learning of important science content, as well as learning to engage in inquiry practices such as careful observation—but do not emphasize the connection between the inquiry practices and the content learning, and do not emphasize the role of evidence-based explanations in science). Although Catie shifted in her thinking about learning goals, the shift was not toward full alignment with the goals espoused in the CASES curriculum materials, and does not seem to reflect a stance that inquiry practices can promote deep understanding of science content. On the other hand, Catie also experienced a shift in her thinking about curriculum materials, and may thus have developed in an aspect of her curricular role identity (Forbes & Davis, 2007) as a result.

Maggie appears to be a high pedagogical design capacity teacher, as described by Brown (in press). She can effectively use the curriculum materials she has at hand to meet her needs, drawing on her knowledge of students, other personal resources, and resources within the curriculum materials. Catie's pedagogical design capacity is less straightforward to describe. On the one hand, Catie regularly draws on her personal resources—most notably, her knowledge and beliefs about learning goals as well as her knowledge of students—to make changes to the curriculum materials. These changes are in line with her intentions. On the other hand, she dismisses resources within the curriculum materials themselves that might help her recognize the potential role of constructing scientific explanations in building students' science content knowledge (and to recognize the importance of explanation construction as a scientific practice in which it is worth engaging students). What is clear is that Catie's changes to curriculum materials are in line with her own goals for her students and that she may need further support in shifting those goals to be truly in line, in turn, with science education reforms.

We can draw a few important conclusions from this work. First, this study provides support for the stance that teachers likely need support—perhaps especially new teachers—in knowing they can adapt curriculum materials in science. Given new teachers' reliance on curriculum materials in guiding their practice (Grossman & Thompson, 2004; Valencia et al., 2006) and some teachers' lack of a sense of curriculum adaptation as being a part of their professional role (Bullough, 1992; Eisenhart et al., 1998), this perspective bears particular relevance. In addition to this shift in perspective, we must help teachers consider and make productive changes. Beginning teachers may especially need such support in using curriculum materials effectively. Teachers who have a limited knowledge base (as is often the case with beginning elementary teachers of science) who also have access to comprehensive curriculum materials (also often the case in elementary science) may have particular difficulty in

determining productive ways of adapting curriculum materials (Valencia et al., 2006). Some work has explored ways of supporting preservice teachers in identifying and applying criteria for critiquing and adapting curriculum materials (Davis, 2006; Lynch, 1997; Schwarz et al., in preparation). For example, we have found that preservice elementary teachers can apply some important criteria as lenses for exploring curriculum materials in sophisticated ways, though providing appropriate scaffolding seems crucial in helping them be successful (Davis, 2006). Work with classroom middle school teachers indicates that even experienced teachers who are new users of reform-oriented science curriculum materials benefit from ongoing professional development to help them learn to adapt the materials to use in their classrooms (Mawyer, Johnson & Edelson, in preparation). In sum, supporting both a shift in perspective or orientation toward curriculum materials, as well as developing real skill in analyzing and using curriculum materials, is crucial.

Second, this study provides further evidence that teachers' learning goals and their knowledge of their students play important roles in influencing how a teacher adapts curriculum materials. Other research has consistently identified teachers' desires to make curriculum materials "work for their students" as a major influence on how teachers change curriculum materials (e.g., see Remillard & Bryans, 2004; Valencia et al., 2006). Teachers' learning goals have typically been included under a broader umbrella describing the teacher's beliefs about teaching her or his subject matter, and those beliefs are also identified as central (e.g., Collopy, 2003; Drake & Sherin, 2006). Identifying these—knowledge of students and learning goals—as two key factors in how teachers think about adapting their curriculum materials means that these may be productive areas of focus for teacher educators, providers of professional development, and developers of educative curriculum materials, as we discuss below. Although researchers, developers, and practitioners emphasize that when teachers change high-quality curriculum materials, the changes should maintain the integrity of the design and work toward the same learning goals (Ben-Peretz, 1990; Bridgham, 1971), we know that in reality this is not always the case (e.g., Schneider & Krajcik, 2000). Perhaps by supporting teachers in considering two of the key factors in making such changes, the changes can be more productive.

Third—and closely related to the above point—this study demonstrates that when a teacher's learning goals are not aligned with those in the curriculum materials, the teacher's adaptations may work against the intentions embodied in the written curriculum materials. Previous research, as noted above, describes how a teacher's beliefs about teaching particular subject matter influence how she or he uses curriculum materials (e.g., Collopy, 2003). This study extends these existing findings by showing how even very subtle differences in subject-matter learning goals can have a profound impact on how a set of curriculum materials will be enacted. For the most part, we view Catie's orientation toward science teaching to be far closer to the CASES orientation than that of most typical elementary teachers. For example, elementary teachers tend to emphasize activities that are both reliable and engaging (Appleton, 2002) and/or tend to avoid teaching science altogether (Appleton, 2007; Davis et al., 2006). Catie was enthusiastic about teaching science and worried about providing a coherent learning experience for her students. But because of a few subtle but crucial differences between Catie's orientation and that incorporated into the CASES materials, Catie removed the existing emphasis on scientific explanation.

Fourth, the act of writing these narratives grounded in curriculum materials did serve as a professional development experience for the teachers, but not as profoundly as we originally hoped it might. Although both teachers did grow in some important ways, this professional development experience was a fairly time-intensive form of support, with relatively limited positive impact on the participants. The preservice and beginning teachers who will read the narratives Maggie and Catie wrote to include in the CASES educative curriculum materials will likely benefit more from Maggie's and Catie's work than did Maggie and Catie themselves; we have evidence from other studies of the benefits to preservice teachers of reading and reacting to such narrative images of inquiry (see Dietz & Davis, accepted pending revisions; Smithey & Davis, 2004).

These conclusions have implications for teacher education, professional development, and educative curriculum materials. For example, those who develop or provide these learning opportunities for teachers should work to support teachers in at least understanding the learning goals espoused by the curriculum materials. Developing a deeper and richer understanding of the learning goals actually espoused by the curriculum materials would help teachers identify matches and mismatches with their own learning goals. Furthermore, specifically with regard to educative curriculum materials, providing rationales in educative curriculum materials to justify instructional recommendations (Ball & Cohen, 1996; Davis & Krajcik, 2005) may contribute to this goal, as these rationales could be a location in which explicit connections could be made between learning goals and instructional decisions. Potentially, such an understanding might also help teachers shift toward greater alignment. In particular, teachers may need support in identifying the crucial connections between engaging in inquiry practices and developing science content knowledge, rather than seeing these as two unrelated types of goals (NRC, 2007).

In addition, teacher education, professional development, and educative curriculum materials should help teachers develop strategies for knowing their students, including their students' specific ideas about scientific phenomena, their family situations, and their school context. This improved knowledge of their students would help teachers be better positioned to make productive changes to the curriculum materials. Preservice teachers may make the most progress on identifying their students' specific ideas about scientific phenomena (Smithey & Davis, 2007) whereas classroom teachers may be better able to consider wider contextual issues such as students' family and home life. Within educative curriculum materials, incorporating questions and prompts to help teachers consider how their students might experience the lessons might be a helpful feature.

Future research should explore how preservice and beginning teachers use and learn with these authentic narratives as opposed to the fictional ones originally incorporated into the curriculum materials (and which have thus far been the focus of our learning research; Dietz & Davis, accepted pending revisions; Smithey & Davis, 2004). The focus and situativity of the narratives, grounded in actual lesson plans and in teachers' own experiences, may make them especially powerful (Putnam & Borko, 2000; Wilson & Berne, 1999). Future research should also continue exploring the notion of teachers' pedagogical design capacity (Brown, in press). This theoretical construct may make an important contribution in connecting research on teachers' cognition and their practice.

In sum, Maggie and Catie, in different ways, explored and articulated their own thinking about and priorities in science teaching and the ways in which those priorities shaped their curriculum use. We use their experiences to inform our understanding of how teachers adapt curriculum materials—what kinds of changes do they make, and on what basis do they decide to make those changes. Most importantly, we see this study as informing the work of science teacher educators, providers of professional development for science teachers, and developers of educative science curriculum materials as we move forward in helping elementary teachers be effective users of science curriculum materials.

Appendix A: Prompts Given in Online Discussion Space and via Email

Prompts given via email: Defining your theme

How do you define your theme?

- What are some of the key words and ideas that fit within your theme and how do you define them?
- What are some of the big ideas that you want to address within your theme?

As you get ready to write your Images for this unit, it might be helpful to look back at the CASES journals and/or daily logs that you wrote at the time that you were teaching the unit.

Prompts given via the online discussion space: Draft profile

Post your draft profile of yourself here. You'll want to describe your setting and your teaching experience, and also talk a bit about why you are focusing on your theme.

Prompts given via the online discussion space: Exploring Ideas

The following questions will help you think about your experiences with this lesson and in formulating your ideas for what you might write about for this lesson. Remember, these questions are intended to be a guide. Feel free to use these simply to spur your thinking rather than feeling obligated to answer each one separately.

1. If you taught this lesson before, describe how you taught it. It might be helpful to look back at the CASES journals and/or daily logs that you wrote at the time that you were teaching the lesson.
    - Describe the steps you took in teaching this lesson. Also describe any changes you made to the lesson and if they were successful or not.
    - Explain what you might do differently if you were to teach this lesson again.
2. Regardless of whether you taught this lesson before, describe the ideas related to your theme that you might want to write about for this lesson:
    - Describe how you think this lesson relates to your Image theme.
    - What do you think are some strengths of this lesson with regard to your theme? In what ways might you build on these strengths?
    - Have you identified any potential problems with this lesson with regard to your theme? In what ways might you refine this lesson to address these issues?
3. Do you have any other experiences that might give you some ideas about what to write about for this Image? Is there anything else that you want to note about writing this Image?

Prompts given via the online discussion space: Deciding what to highlight

The following questions will help you to narrow your various ideas down to one idea for each lesson.

1. Decide on and summarize in one or two sentences one issue or idea to highlight in the Image for this lesson. This might focus on a way to refine the lesson or something you've done in your own practice to emphasize or promote your theme.

2. Explain why this is a good focus for the Image.
    - Why you think the lesson should be refined or taught in this way? Add any thoughts beyond what you've already written.
    - What does this idea have to do with your theme? Add any thoughts beyond what you've already written.

Prompts given via the online discussion space: Drafting the image

Now you're ready to begin drafting the Images (the stories). Things to keep in mind:

- Keep in mind your audience.
- Keep in mind your theme and the main ideas you think are related to it.
- Describe how you recommend refining the lesson or emphasizing the theme in your practice.
- Explain why you make these decisions. You may want to draw on the advantages and disadvantages you thought about before.
- Although the existing Images are written in third person, it probably will be more comfortable to write yours in first person.

Appendix B: Maggie's Images

Lesson 1: Establishing Daily Weather Observations:

Making observations of daily weather is such a great way for students to become involved in this unit. When I was getting ready to teach this lesson, I previewed the worksheet that was provided on the CASES site and noticed that it was not going to work "as is" with my third grade students. Some of the information that was being collected would have been way above the heads of my students. I didn't think it was appropriate to have my students collect air pressure, humidity, and estimated wind speed because they would not have any clue what these data meant. I modified the worksheet so that students could easily record observations (something my students really needed to work on) of the weather in their environment. I made each day an entire page with lines for observation sentences and boxes for pictures of clouds they observed. Many of my students do not have computer access and language issues can get in the way of watching a weather report, so the only numerical data they collected each day was temperature, which they could get off the time/temperature in the corner of their television screen or preferably from the classroom thermometer. As our collective knowledge grew, students were required to include more specific weather vocabulary (e.g., types of precipitation, names for various clouds, and the weather these clouds might bring). Overall, these modifications made daily observations less intimidating and more meaningful for my students.

In addition to making modifications within this lesson, I also added another lesson to this week. The unit calendar section of CASES sometimes provides suggested additional lessons for each week. I chose to add the lessons on making a barometer, types of clouds, reading a thermometer, and knowing benchmark temperatures. I added these lessons, in part, because I teach science four days a week, but I also added them because my students needed more experience with the weather concepts of temperature, air pressure, and clouds.

Lesson 2: What Causes the Wind?

Knowing that the concepts in this lesson had been an extremely difficult for my fourth grade students in the past and knowing that my third grade students already suffered from a lack of science background knowledge, I decided to modify this lesson. I wanted my students to have a solid understanding of air and wind before presenting the idea that wind is caused by a difference in air temperatures. I spent four days leading up to the CASES lesson using a read aloud book called 'I Face the Wind' by Vicki Cobb. This book had many learning experiences that students could try to help them understand wind. We did many quick activities including catching wind in a plastic grocery bag to see that wind is made of air to weighing inflated and deflated balloons to see that air had weight. All of these experiences prepared my students for the more difficult concept they encountered in the CASES lesson. Sometimes I get nervous that teaching all of these other lessons might somehow "give away" the inquiry aspect of the CASES lesson. However, even in using the Cobb book, the students still worked through the experiences in groups and developed their own understanding and conclusions about these activities as well. In the end, I noticed that my third graders had a much more solid understanding of air and wind than my fourth graders in years past.

Lesson 3: Where Do Puddles Go?

This lesson has always been an eye-opener for my students. As I have mentioned before, my third-grade students have needed more experience with making observations. Thus, I decided to modify the first part of this lesson. Instead of showing my students pictures of a puddle and the same location the next day, we made our own puddle. On Day 1 of this lesson (first thing in the morning) my students followed me outside with a bucket of water and a piece of chalk. We made a puddle by dumping out the water and we traced around the border of the puddle with chalk--this took about 5 minutes. When it was "science time" that afternoon, we started by walking out to observe our puddle. The students noticed that only our chalk outline of the puddle remained. We used this experience and observation to kick off the lesson. I think that seeing the phenomenon of evaporation happen over the course of the day helped them prepare for the experiment we were about to do. It was also a great experience for practicing observation skills. Another modification I made to this lesson was to continue my science content Word Wall. As we learn new vocabulary in science (evaporation, in this case), we add the word to the science word wall. We do many activities over the year to review word wall words. Though it does take a little time to review the words daily, weekly, or following a unit, allowing students to have a visual reference to science vocabulary, as well as focusing on science vocabulary, has really helped my students to be able to discuss science more easily by having the ability to employ vocabulary when they talk (i.e., being able to find the correct and accurate word).

Lesson 4: Cloud Formation

This lesson takes extremely close observation skills. The change that students see in the salt grains is very

slight. Therefore, I thought that one thing that was missing from this lesson was a means for students to record observations. I modified this lesson by making a graphic organizer to help my students focus on their observations. The sheet simply had lines to record observations in words and a box to draw a quick sketch of the salt grains. Since this was the first time I had used this observation sheet, I realized that sketching and writing took about 10 minutes instead of 5 minutes. But I liked having students take this extra time because having them record their observations provided me with the opportunity to discuss the changes with my students. I knew that I wouldn't be able to complete a read aloud on clouds with the students while they were busy sketching and observing, so I was sure to read it earlier that day (in our reading instruction). I also made a big deal of talking about "making a cloud in the classroom" so the students kept their focus on how this experiment related to clouds. A second modification that I made to this lesson as well as others was to use an exit slip. This is simply a half sheet of paper with a question copied at the top that students need to answer at the end of the lesson. It helped me assess who picked up the concept, what misconceptions there were, and who might need another exposure to the concept. For this lesson, I asked, "How would you explain how clouds are made to your first grade reading buddy?" I looked for answers to include a description of condensation nuclei, as well as the processes of evaporation and condensation.

Lesson 5: What Causes the Seasons?

One of the largest misconceptions my students have had over the years is the reason for the seasons. While this lesson is a terrific experience for the students, I modified the lesson to include a few more similar experiences to really drive the point home. After students have had the experience with the globe, I also provided them with small Styrofoam balls and dowels. We put the dowels through the balls to create the axis tilt. Students also drew the equator on the balls and placed an X where we would be on the globe. In my experiences students were better able to see the light from the lamp on the white Styrofoam ball. My students also used their hands (tilted as if it were the globe on its axis) to move around the lamp. This helped them feel the heat difference on their hands. I have a small class of 18 this year, so guiding them through this part of the activity one-on-one was not too time consuming and allowed me to make sure that they didn't move their hand position as they moved around the lamp. Since my students lack a great deal of background knowledge, it was so helpful to have multiple experiences that reinforced the same concept.

Appendix C: Catie's Images

Lesson 1: Finding Seeds in Fruits:

I have thought a lot about what is the best way to help students organize their data. Though there is no perfect technique for this lesson, I decided that I wanted to focus more on comparing and contrasting seeds. I think that it is important for students to practice this skill because it is key in inquiry learning. I chose to use a foldable to help students in their comparisons because it seemed appropriate for this task. The particular one I used involved folding a piece of 9x12 white paper in a hamburger fold (9 inch side to 9 inch side) twice and then opening it up, creating 4 columns. I then folded the first and fourth columns to the center and then folded it into thirds from the bottom up. After opening it back up, I had 6 squares. I then cut on the TOP LAYER ONLY to create 6 doors. The pictures of the fruit went on the door and the pictures of the seeds and words to describe them went inside.

During the process, I found that creating a foldable was challenging for young students since fine motor skills are still developing in this age group, but this project was great practice for them. Also, since the fruit was drawn on the top of the flap and the seed underneath, comparing the seed to the fruit from which it came was challenging for students. So, I chose to focus on comparing the seeds to each other since the seeds could all be viewed simultaneously when all the flaps were open. I asked my students, 'Were some bigger than others? Were they different shapes or colors? Were there some that looked the same as others?' The other problem I encountered was that even though drawing the seed size proportionally wasn't a problem, the picture of the fruit was ultimately smaller than its real size. I think a good solution to this problem is to use a piece of 12x18 paper instead. This way there is also space for answering questions or making predictions. If you choose to focus on the seeds though, size of the paper doesn't matter as much. Lastly, I like the foldable technique because it helped me to know how much effort and learning each of my children had accomplished.

Lesson 2: Grouping Seeds:

Organizing a unit is key for a teacher, but we sometimes forget that children need to learn and apply organizational skills as well. I wanted to focus on encouraging the children to organize the activity that they were doing. In this lesson, I gave the children a handful of different seeds and asked them to group them in various ways. The problem I faced last year when I taught this lesson was pushing the students beyond the basic groupings of color and size. The simplicity of these groupings caused the second graders to finish quickly without putting much thought into what they were doing. I wanted the students to extend themselves into being creative with their groupings. This year, I began by telling the students that they had to group their seeds in 3 different ways. I wanted to tier them, in that, I wanted the students to go from an easy grouping to a more challenging grouping and finally to the most complex grouping. I listed the eight suggested groupings from the lesson plan on the board and said that these were some examples they could use. Following this statement, I circled the word 'size' and 'color' in red and told them they could choose one of these ways to group their seeds first. I then circled the rest in green and said that they could choose one of these ways to group their seeds second. Lastly, I circled an empty space on the board and said, 'This is your creativity box. In your groups I want you to think of a new and different way to group your seeds. When everyone is done, we will share our ideas and put them in the blue box.' Overall, this lesson can be used to teach the essential skill of classifying. We need to teach our children how to use and perfect this skill.

Lesson 3: Looking at How Seeds Move:

Before I discuss the method of organization that I suggest, let me mention first that I modified this lesson slightly. Due to time restrictions and unavailability of parks to search for seeds, I did not have the children gather seeds but instead gave them seeds to figure out their methods of movement (water, wind, sticking). My second graders have been working all year on placing data in different organizational formats. In doing this activity, I wanted them to apply a method that they were already familiar with, creating a data table with titled columns. Let me emphasize that the idea was not for the children to follow a set format in creating their data table but to make it clearly organized so others could understand it and/or so the students could explain it to others even after coming back to it after several days. I thought this was difficult, however. When I monitored each child carefully, I could get the majority to produce some good work. Although the charts weren't perfect, it gave the children practice using organizational methods that they have been exposed to. It was important for them to apply these methods in order to become more comfortable with and skilled at using them. Another great advantage of this lesson was that the children were encouraged to apply organizational methods to increase their learning about how seeds move and were being challenged and thus had opportunities to improve on their fine motor and spatial skills.

Lesson 4: Observing Seed Parts:

During a lesson of this kind, teachers have the opportunity to focus on another important organizational skill, drawing accurately and labeling. Scientists draw sketches, which are labeled and colored, so that others have a clear picture of what they are attempting to explain. In this lesson, the children were asked to draw what they saw when examining a lima bean's exterior and interior. This was a tricky part! How do I get them to go beyond the oval they just drew? I tried very hard to focus on this skill of drawing accurately in every lesson because it was hard for students to master. I have learned this year how to help students draw accurate, labeled pictures. I walked around and offered suggestions for how to improve pictures and refocused those who were off track. I also demonstrated how to observe a different seed and drew the seed with color, detail, and labels so they knew what I was expecting. These three components were important for the picture to be organized enough for others to understand it, especially since the kids and I weren't the best artists. A disadvantage of organizing pictures cropped up when I considered the size. When drawing something small (like seeds), do I sacrifice the actual size of the object in favor of more details or do I sacrifice the details in order for the size to be accurately represented? Time can also be a restriction. Accuracy and details, like color and labels, take time to properly execute. I worried that I wouldn't be able to give the children adequate time to do a good job. However, since this type of skill is important, tackling it made science learning richer. Additionally, I found that detailed drawings can be applied in any lesson I teach in science as well as in other subjects, so it was worth the practice!

Lesson 5: Do Plants Need Sunlight:

This lesson is fantastic for science inquiry. However, the worksheets provided in this unit, although nicely set up, were not ideal for having students compare within their own observations or with another classmate, which is what I wanted to emphasize with this lesson. This year I created a worksheet where several observations could be placed on a single page. This was easy to do in Microsoft Word using text boxes. I gave each child two observation sheets which we glued side-by-side on a sheet of 12x18 paper that was folded in half in order to create a book. Here we were able to document the entire investigation in one flowing space. One disadvantage that I found with this method was that the pictures had to be drawn smaller and hence, less detail was captured. To address this issue, I created larger text boxes, which only allowed 2 observations to fit on a page but gave each child more space for detail. I didn't want to create a situation where less information was being shared or compared. However, creating slightly larger boxes to remedy this problem meant fewer observations took place throughout the investigation, but the extra details made it worthwhile. The children were still able to compare the changes in their plant with each passing observation and to compare what happened to their plant with changes in their classmates' plants. Next time, I might have my kids create multiple 'books' for the duration of the investigation.

Lesson 6: Asking Questions About Plants:

In this particular lesson, flexible organization is a good goal. This lesson is intended to be about the students' thoughts and questions, not how the teacher can structure the data. Therefore, I would focus more on organizing a type of free-write. I would have the children record the questions the class has about plants and would have them leave about 5-6 lines in between each one. These spaces would later be used for the answers to the questions that THE CHILDREN discover. I would also allow them to use different colors when recording the answers to help distinguish them from the questions. I might also decide to assign properties to the colors. For example, I might use green for an answer they found and red for an answer another group found or blue for 'I know this is the right answer' and orange for 'I'm only sort of sure about my answer'. One thing that inevitably happens during inquiry lessons is that experiments do not always yield the result I would like. Sometimes the answers the children write aren't scientifically correct based on their own experiment. To address this issue, I usually make sure there were at least 2 groups working on the same question. That way, hopefully one of the groups will get the "right" result, which can then be used as an example for the rest of the class. As a comparison, I might even have the children discuss the differences and why they have occurred. An advantage of using this strategy for having the children write their questions and answers is that the children are writing in an informational/investigational setting, which is important at this age. Also, the children may be more enthusiastic about writing in colors and may want to write more. Lastly, the students are in a cooperative setting where they can share what was learned with their classmates and have time for questions and an opportunity for discussion using their written work, which is a practice that real scientists do.

Lesson 7: Investigating Plants:

This lesson is extremely dependent on the children's questions so the organizational technique that is applied in this setting may vary slightly. Most questions lend themselves to the worksheet in this lesson. However, some require a data table if, for example, the students are recording color change in the leaves. Some may require graphs if, for example, the students are measuring heights of plants over a period of time. Still other groups may need some other sort of organizational system to help with their investigation. In addition to these items, I think that the color-coded question/answer pages the children created in the previous lesson may be useful throughout these investigations since every child isn't doing every investigation but still needs to learn from what others are doing. There is one main disadvantage to these suggestions, which is that the children may not necessarily be introduced to another organizational technique that they may find helpful. However, the advantage is that the students and teacher may have another chance to practice with one of the organizational systems mentioned earlier, which can be beneficial for everyone's learning.

Lesson 8: Field Trip

This final lesson focuses on organization of a field trip. Field trips can be stressful and teachers want to make sure they are worthwhile and educational before they spend precious time and resources on them. I personally have never done this lesson because the logistics of taking 30 second-grade students on a field trip of this nature has never worked out for me. Therefore, I want to focus on what I would do with the students if I were able. My focus would be on organizing the questions the children ask on the trip. I would begin by having the children brainstorm a list of questions they want to ask while they are at the farm/grocery store. Then, depending on the number of kids in my class, I would assign each pair 1-2 questions that they would be responsible for answering and recording information for. They would become the 'experts' who would 'teach' the class about their questions/answer when they return. A disadvantage of this method is that children have poor fine motor skills and may become overwhelmed with writing. Also, once they find out the answer to their question(s), they may ignore the other questions. They may also become so involved with writing their answer or distracted by their paper and pencils that they may lose focus on what else is going on. Then again, these problems may have happened anyway. Advantages are that each child will have something to contribute to the class when they return instead of only a handful of children who listened and know EVERYTHING!! Plus if a student missed something on the field trip or if there was a child absent, the presentation of answers may be a good review/reminder of the overall lesson for those who missed some or all of it. Assigned questions may also give every child a sense of responsibility and importance to know that they are in charge of something. Especially at the age of 7 or 8, this is a great quality to instill in them.

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