USING REFORM-BASED CRITERIA TO SUPPORT THE DEVELOPMENT OF PRESERVICE ELEMENTARY TEACHERS' PEDAGOGICAL DESIGN CAPACITY FOR ANALYZING SCIENCE CURRICULUM MATERIALS

by

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DEDICATION

To my husband Chris and daughter Madelyn Joy

For your motivation, support, and love.

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ABSTRACT

Effective science teachers use curriculum materials as a guide in their planning, critiquing and adapting them to promote inquiry-oriented, standards-based teaching and address specific contextual needs. Unfortunately, many preservice teachers encounter difficulties with these design tasks, making changes that are inconsistent with science education reform efforts or failing to make much-needed modifications. To help them become well-started beginners in analyzing curriculum materials, preservice teachers need opportunities to develop their pedagogical design capacity—that is, their ability to use their knowledge and beliefs, along with resources within curriculum materials, to design instruction for students. However, how teacher educators can support preservice teachers in developing this capacity has been largely unexplored in the literature.

This dissertation addresses this gap by investigating the use of reform-based criteria in scaffolding the development of an analytical stance toward curriculum materials. Twenty-four preservice teachers from one section of an elementary science methods course participated in this study, with a subset of seven followed into their student teacher semester. In learning about and applying criteria during the course, the preservice teachers developed aspects of their pedagogical design capacity for curricular planning. Many of them adopted a criterion-based approach to analysis, expanded their analysis ideas, and refined their beliefs about curricular analysis. However, the preservice teachers struggled with engaging in authentic analysis tasks during the course and

maintaining a principled, reform-based approach to analysis during student teaching. This may have occurred, in part, because the scaffolds within the course were faded before the preservice teachers could develop the capacity to engage in curricular planning on their own using curriculum materials from their field placements, which tended to be poorly aligned with reform-based science teaching goals. This finding may also have occurred because their cooperating teachers expressed different reasons for adapting materials than what was presented in the course. The methods course emphasized the importance of modifying materials to make them more consistent with reform-based practices, but few preservice teachers observed teachers make adaptations for this reason. These findings have important implications for theoretical models on curriculum materials use and the design of science teacher education and curriculum materials.

CHAPTER 1

INTRODUCTION

Effective teachers use curriculum materials as a guide as they make thoughtful decisions about instruction for students. They critique and adapt materials in order to address reform-based standards and practices, individual students' needs and strengths, and local circumstances (Ben-Peretz, 1990; Barab & Luehmann, 2003; Brown, 2009; Remillard, 1999). Unfortunately, preservice teachers face a number of obstacles as they engage in this design work and thus are in need of support. However, relatively few studies have examined the ways in which preservice teachers analyze curriculum materials and how teacher educators can support them in doing so (Lloyd & Behm, 2005; Nicol & Crespo, 2006). Specifically, preservice *elementary* teachers' critique and adaptation of *science* curriculum materials has been largely unexplored in the literature (Davis, 2006; Schwarz et al., 2008). Additionally, little is known about preservice teachers' beliefs about the curriculum materials development process and the ways in which teacher educators can support them in seeing design work as a relevant part of their practice. This dissertation investigates this understudied yet important area of research by examining how the use of reform-based criteria provided in a science methods course can support preservice elementary teachers in developing an analytical stance toward curriculum materials and a nuanced perspective on the role of curriculum materials in practice.

Role of Curriculum Materials in Authentic Practice

Curriculum materials are written resources designed for teachers to use with students during instruction. These materials contain content and skills for students to learn, provide activities to promote learning about those ideas, and suggest sequences for these activities (Remillard, 2000). Curriculum materials come in a variety of forms, including printed, often published, resources such as textbooks, teacher guides, and science kits, as well as unpublished lesson plans developed by individual teachers or groups of teachers at local schools. In addition to their many shapes and sizes, curriculum materials also vary in their pedagogical approach shaped by developers' underlying assumptions about the subject matter, teaching, and learning. Additionally, these written resources differ in their degree of comprehensiveness and specificity, that is, in how much detail they provide teachers about content and pedagogy (Kauffman, Johnson, Kardos, Lui, & Peske, 2002; Remillard, 2005).

Curriculum materials are typically found in most classrooms and are intimately connected to teachers' daily work (Ball & Cohen, 1996; Collopy, 2003). Teachers often use curriculum materials to address district and state level curriculum frameworks, which define the learning goals for what students should know and be able to do as a result of instruction (Lynch, 1997, Remillard, 2005). Teachers also use these curricular tools to guide their planning and enactment of lessons (Ball & Cohen, 1996; Brown, 2009; Kesidou & Roseman, 2002; Lloyd, 1999; Remillard, 2005; Shulman, 1986). Additionally, teachers teaching outside their content area and teachers entering the field of teaching tend to rely extensively on such materials to plan and deliver instruction (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Kauffman, 2002; Kauffman et al., 2002;

Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Powell, 1997). "Of all the different instruments for conveying educational policies, [curriculum materials] exert perhaps the most direct influence on the tasks that teachers actually do with their students each day in the classroom" (Brown & Edelson, 2003, p. 1).

Curriculum materials also serve as a site for teacher learning. Some materials are explicitly designed to support teacher learning (Beyer & Davis, in press-a, in press-b; Collopy, 2003; Remillard, 2000; Schneider, 2006; Schneider & Krajcik, 2002). Other curricular resources promote teacher learning more implicitly through teachers' use of the materials to plan instruction, enact teaching approaches suggested in the materials, and reflect upon their enactments (Ball & Feiman-Nemser, 1988; Collopy, 2003; Grossman & Thompson, 2004; Nicol & Crespo, 2006; Remillard, 2000; Wang & Paine, 2003). These curricular interactions provide teachers with "events or activities that are likely to unsettle or expand teachers' existing ideas and practices by presenting them with new insights or experiences" (Remillard & Bryans, 2004, p. 358). Such events provide a variety of opportunities for learning, including helping teachers develop insights into the subject matter, explore different ways of organizing content for instruction, expand their repertoire of activities and instructional approaches for promoting student learning, and examine student thinking as learners respond to tasks during instruction. Providing opportunities for teachers to use and make meaning of *reform-oriented* materials, specifically, can prompt them to consider new perspectives on teaching and learning, and in turn, refine their beliefs and adopt reform-oriented practices (Collopy, 2003; Petish, 2004; Remillard, 2000; Remillard & Rhude-Faust, 2006; Schneider, 2006; Schneider & Krajcik, 2002; Spielman & Lloyd, 2004).

In summary, curriculum materials play a central role in teachers' work by helping them design and enact instruction as well as serving as a source for new learning.

Critiquing and Adapting Curriculum Materials as Authentic Teaching Practices

A growing body of research has focused on how teachers use science and mathematics curriculum materials to design and enact instruction (Ben-Peretz, 1990; Collopy, 2003, Davis, 2006; Enyedy & Goldberg, 2004; Fishman, Marx, Best, & Tal, 2003; Heaton, 2000; Lloyd, 1999; Palincsar et al., 1998; Petish, 2004; Pintó, 2004; Remillard, 1999; Remillard & Bryans, 2004; Schneider, Krajcik, & Blumenfeld, 2005; Schwarz et al., 2008; Sosniak & Stodolsky, 1993). In investigating teachers' use of curriculum materials, this body of research has shown that effective teachers hold an analytical stance toward curriculum materials, critiquing and adapting them to achieve productive instructional ends. Critiquing materials here refers to evaluating a set of written materials by identifying its strengths and weaknesses (Davis, 2006; Schwarz et al., 2008; Sherin & Drake, 2009), and adapting materials refers to making changes to lesson plans to promote opportunities for student learning (Davis, 2006; Drake & Sherin, 2006). I use the term 'analysis' to refer simultaneously to both practices.

Teachers critique and adapt curriculum materials for two primary reasons. First, school districts routinely adopt and mandate the use of published curricular programs (Ball & Cohen, 1996; Ball & Feiman-Nemser, 1988; Remillard & Bryans, 2004). These materials equip teachers with much needed resources but vary in quality. For example, recent reviews of science curriculum materials show that many existing curricular programs are inconsistent with reform-based standards and practices (Beyer, Delgado, Davis, & Krajcik, in press; Hubisz, 2003; Kesidou & Roseman, 2002; Ochsendorf, Lynch, Pyke, O'Donnell, & Faubert, 2004; Stern & Roseman, 2004). The programs fail to establish a sense of purpose, attend to students' alternative ideas, provide relevant phenomena and representations to illuminate abstract concepts, and scaffold students in making sense of key ideas. Poor quality materials do not adequately support students in achieving important content and inquiry learning goals and thus need to be critiqued and adapted in order to overcome these limitations.

Second, curriculum developers typically design curriculum materials for a wide audience and general context. Thus, teachers need to use their curriculum materials in flexibly adaptive ways in order to meet their specific contextual needs and anchor their students' learning in productive ways (Barab & Luehmann, 2003; Brown, 2009; Enyedy & Goldberg, 2004; Pintó, 2004; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). Russell (1997) appropriately explained:

> No matter how well curriculum materials are tested, no matter how many times they are revised, each school brings its own mix of resources and barriers, each classroom brings its own set of needs, styles, experiences, and interests on the part of both teacher and students, and each day in the classroom brings its own set of issues, catastrophes, and opportunities. (p. 251)

Thus, in creating learning experiences for students, teachers necessarily make local adaptations to curriculum materials given their own understandings and goals, particular students' needs and strengths, and classroom circumstances.

In summary, curriculum materials need to be critiqued and often times adapted in order to address reform-based standards and practices and attend to local circumstances. For these reasons, it is imperative that teachers know how to identify strengths and weaknesses and make productive adaptations in order to benefit from the affordances of curriculum materials while making up for their deficiencies.

Learning to Critique and Adapt Science Curriculum Materials—Argument for Supporting Preservice Elementary Teachers

Teachers' pedagogical design capacity plays a key role in shaping their ability to critique and adapt curriculum materials (Brown, 2009). This capacity is not just a function of having particular types of knowledge and beliefs. It also includes the ability to act upon these personal resources while interacting with particular curricular resources in order to design powerful learning opportunities for students (Cohen & Ball, 1999; Remillard, 2005). Thus, in developing their pedagogical design capacity, teachers must learn how to negotiate the affordances and constraints of particular curricular features while taking into consideration their own understandings, instructional goals, and classroom needs.

Unfortunately, in cultivating the capacity to critique and adapt curriculum materials, preservice and early career teachers encounter many obstacles (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Lloyd & Behm, 2005; Mulholland & Wallace, 2005, Nicol & Crespo, 2006; Schwarz et al., 2008; Valencia et al., 2006). (I use the term 'beginning teachers' to refer to both preservice and new teachers.) For example, beginning teachers tend to have weak science content understandings and limited pedagogical content knowledge for science teaching—that is, limited knowledge about how to teach specific subject matter (Abell & Roth, 1992; Cochran & Jones, 1998; Lederman, Gess-Newsome, & Latz, 1994; van Driel, Verloop, & de Vos, 1998; for a review, see Davis, Petish, & Smithey, 2006). Additionally, critiquing and adapting curriculum materials requires time, which beginning teachers have very little of since they are preoccupied with the high demands of being a new teacher (Abell & Roth, 1992; Appleton & Kindt, 2002). This is especially true for beginning *elementary* teachers who have to teach several other subjects in addition to science (Weiss, Banilower, McMahon, & Smith, 2001). These constraints and others limit these teachers' capacity to critique and adapt science curriculum materials in productive ways.

Given these challenges, why should teacher educators even try to help beginning elementary teachers develop their pedagogical design capacity for analyzing science curriculum materials? I propose the following reasons. First, studies have shown that beginning teachers tend to be uncritical users of curriculum materials, relying heavily upon them to determine what and how to teach (Ball & Feiman-Nemser, 1988; Bullough, 1992; Grossman & Thompson, 2004; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Remillard & Bryans, 2004; Schwarz et al., 2008; Valencia et al., 2006). Some teachers use curriculum materials in this way because they do not see that analyzing curriculum materials is an authentic teaching task. Others have not had the opportunity to develop particular aspects of their knowledge base essential for modifying materials. This use of curriculum materials is problematic because beginning teachers may not discern the affordances and constraints in their curriculum materials. Consequently, they may fail to make much-needed modifications to improve the materials or may inadvertently make counterproductive changes—omitting or changing parts of lessons essential for supporting student learning (Ball & Feiman-Nemser, 1988; Brown & Campione, 1996; Grossman & Thompson, 2004; Lloyd & Behm, 2005; Nicol & Crespo, 2006; Valencia et al., 2006). Therefore, teacher educators need to help beginning elementary teachers become intelligent, analytical users of curriculum materials in order to help them use curriculum materials in ways that will best support student learning.

Second, in an ideal world, beginning teachers would simply need to develop the knowledge and skills for differentiating good curriculum materials from bad and use the good materials with their students. However, as mentioned above, some school districts adopt a particular curricular program and mandate its use. This curricular context provides teachers with little flexibility in using other curricular resources (Lloyd, 1999; Valencia et al., 2006). Having to use a particular set of curriculum materials may be even more problematic since science curriculum materials are often poorly aligned with grade-level standards and reform-based teaching practices (Beyer et al., in press; Forbes, in preparation; Hubisz, 2003; Kesidou & Roseman, 2002; Stern & Roseman, 2004) and poorly matched with their particular students' strengths and needs (Barab & Luehmann, 2003; Pintó, 2004; Squire et al., 2003). Other beginning teachers work in school districts where they are not provided with any curriculum materials, leaving them to scavenge for relevant resources and attempt to put together coherent lesson plans (Kauffman, Johnson, Kardos, Liu, & Peske, 2002). For these reasons, it is crucial that beginning elementary teachers develop the professional knowledge and skills they need in order to design high-quality learning experiences for students.

Third, even though it is important that teachers analyze their curriculum materials for all subject areas in order to make them accessible to their specific students and contexts (Barab & Luehmann, 2003; Enyedy & Goldberg, 2004; Pintó, 2004; Squire et al., 2003), they may only need to analyze their *science* curriculum materials in order to improve their overall quality. For example, in a 2000 national survey of teachers in schools across the United States, Weiss and colleagues (2001) found that more than three-fourths of elementary school teachers perceived their mathematics curriculum materials to be good or better in quality whereas only about half of these teachers had this perception of their science curriculum materials. Additionally, in a 2003 survey of second-year elementary teachers randomly selected from three states, Kauffman (2005) found that these teachers consistently viewed their mathematics and language arts curriculum materials as considerably more supportive than their science curriculum materials. Specifically, in comparison to their science curriculum materials, more teachers viewed their mathematics and language arts curriculum materials as addressing the content that their students needed to learn and providing helpful guidance about how to teach the content to their students. More than twice as many teachers also reported having curriculum-related support—both formal professional development and informal discussions with colleagues or supervisors—for mathematics and language arts than for science. Because teachers tend to be provided with higher quality curricular resources for some subject areas other than science and better professional development associated with those curriculum materials, beginning elementary teachers may need to focus primarily on analyzing their science curriculum materials to improve their overall quality.

Fourth, teachers tend to place a greater emphasis during a typical school day on the academic subjects that are part of high-stakes testing—mathematics and language arts—than on other subject areas, such as science (von Zastrow & Janc, 2004). Specifically, in the 2000 national survey, Weiss and colleagues (2001) found that elementary teachers tended to spend almost two hours of each school day on reading and language arts and nearly one hour on mathematics but only 25 minutes of each day on science instruction. Similarly, as part of the national 2003-04 Schools and Staffing Survey, Morton and Dalton (2007) found that elementary teachers in grades 1-4 tended to spend five times as much time teaching language arts and twice as much time teaching mathematics, in comparison to science. Therefore, with such little time devoted to teaching science, teachers need to make what time they do spend on science more productive.

Finally, some studies have shown that beginning elementary teachers are able to critique and adapt curriculum materials in productive ways when provided with support (Davis, 2006; Lloyd & Behm, 2005; Nicol & Crespo, 2006; Schwarz et al., 2008). In learning how to engage in the design work of teachers, beginning elementary teachers may not be able to address all the weaknesses within their curriculum materials, but they are able to take small steps toward improving them to help students achieve their learning goals. The initial knowledge and skills they develop as beginning teachers will lay the foundation for further learning and growth through their experience as practicing teachers. For these reasons, teacher educators need to provide opportunities to help preservice teachers become well-started beginners in analyzing curriculum materials.

Research Questions and Study Overview

Despite the importance of helping beginning teachers develop an analytical stance toward science curriculum materials, few researchers have studied how to do this—especially with preservice *elementary* teachers and their analysis of *science* curriculum materials (see Davis, 2006 and Schwarz et al., 2008 for exceptions). Consequently, little is known about the ways in which preservice teachers analyze curriculum materials—both within in-class activities and more authentic analysis experiences—and the types of scaffolds that can support them in learning how to engage in productive curricular analysis. Additionally, little is known about preservice teachers' beliefs about the curriculum materials development process and the ways in which teacher educators can support them in seeing design work as a relevant part of their teaching practice.

Toward these ends, this study followed 24 preservice elementary teachers as they experienced a science methods course intended to develop their pedagogical design capacity for analyzing curriculum materials and their beliefs about curriculum materials analysis. The conceptual framework for helping the preservice teachers develop a principled perspective on the analysis of science curriculum materials involved the use of reform-based criteria, that is, criteria based upon what science education researchers know about how students learn science. These criteria were based on the American Association for the Advancement of Science (AAAS) Project 2061 Instructional Analysis Criteria (Kesidou & Roseman, 2002; Stern & Roseman, 2004). By scaffolding the preservice teachers' use of these criteria in analyzing science lesson plans, this study aimed to develop the preservice teachers' understanding of the components of reform-based science teaching—as foregrounded in the criteria. In turn, this study aimed to develop the preservice teachers' pedagogical design capacity for analyzing science curriculum materials—specifically, their ability to recognize the strengths and weaknesses of these materials and make beneficial adaptations.

To investigate the use of reform-based criteria in scaffolding the development of preservice teachers' analysis practices and beliefs, I asked these research questions:

1.) When introduced to reform-based criteria and asked to apply them in their analyses, what are preservice elementary teachers' understandings of the criteria and how do they apply them in their analyses of science lesson plans?

2.) When not explicitly asked to apply criteria in their analyses, how do preservice elementary teachers analyze science lesson plans and how do their analyses change over time?

3.) What are preservice elementary teachers' beliefs about and perceptions of curriculum materials analysis? What reasons do they give for their beliefs and perceptions?

To address these research questions, data were drawn from the preservice teachers' coursework, which included criterion-based analysis tasks using lesson plans provided by their course instructor and lesson plans from their field placements as well as an assignment summarizing what they had learned from their observations of and conversations with their cooperating teacher about his or her planning practices. Data also included pre/posttests, which were open-ended analysis tasks administered at the beginning and end of the course. Additionally, interviews were conducted with seven of the 24 preservice teachers during the methods course and student teaching semester. These data provided insights into what preservice teachers do when they are engaged in the work of analyzing curriculum materials, with and without support, and within more or less authentic teaching experiences. It also shed light on preservice teachers' beliefs about why, how, and when teachers engage in curricular analysis and how these beliefs change over time during the science methods course.

Results show that at the beginning of the methods course, the preservice teachers had limited pedagogical design capacities for designing curricular plans and undeveloped beliefs about curriculum materials analysis. After learning about and applying reform-based criteria, the majority of the preservice teachers developed their capacities to engage in design work—adopting a criterion-based approach to analysis and expanding their analysis ideas—and developed more complete beliefs about when, how, and why teachers critique and adapt curriculum materials. However, during the course the preservice teachers struggled with engaging in authentic analysis tasks, and of those who were followed into the student teaching semester, none of them continued to analyze lesson plans in a principled, reform-oriented way in their placement classrooms. One possible reason for this finding is that the scaffolds within the course were faded before the preservice teachers had the chance to develop the capacity to engage in curricular planning on their own using curriculum materials from their field placements, which tended to be poorly aligned with reform-based science teaching goals. Another possible reason is that their cooperating teachers expressed different ideas about why teachers analyze curriculum materials, in comparison to their methods course. Based on the preservice teachers' perceptions, their cooperating teachers modified for their specific students, teaching styles, and standards but not for reform-based goals and practices—an important reason emphasized in the science methods course.

This study provides insights into theoretical frameworks on curriculum materials use, adding specificity and shedding light on new factors for inclusion. Specifically, this study shows that tools (e.g., reform-based criteria) and multiple contexts (e.g., methods courses, field placements) play an important role in shaping preservice teachers' interactions with curriculum materials. It also sheds light on models of science teacher knowledge, highlighting particular strengths and weaknesses in beginning elementary teachers' knowledge base for science teaching. This study also has important implications for the design of science teacher preparation and induction programs. It provides evidence for the use of reform-based criteria in supporting preservice and new teachers in developing beginning-level skills for critiquing and adapting curriculum materials. It also highlights particular struggles that preservice teachers face in learning about curriculum materials analysis, shedding light on areas in need of additional support. Additionally, this work informs the design of curriculum materials themselves, providing suggestions for how these written resources can help teachers refine their beliefs about curriculum materials analysis and develop their pedagogical design capacity.

Six chapters follow this introduction. Chapter 2 presents a review of the literature on curriculum materials use. I discuss different conceptions of curriculum materials use and elaborate on one theoretical perspective that conceptualizes curriculum materials use as a dynamic, collaborative relationship between the teacher and curriculum materials. I also discuss the challenges that preservice and new teachers face within this participatory relationship. Chapter 3 details the methods used to address the research questions dealing with the use of reform-based criteria to scaffold preservice teachers' critique and adaptation of science lesson plans. I describe the instructional context, research participants, data sources, and coding and analysis procedures. Chapters 4, 5, and 6 present the results. Chapter 4 presents findings on how preservice teachers critique and adapt science lesson plans by providing insights into what criteria they attend to in their analyses, how well they address reform-based criteria, and where they need further support. Chapter 5 sheds light on changes in preservice teachers' pedagogical design capacity for analyzing curriculum materials after learning about a criterion-based approach to analysis and reform-based criteria, specifically. Chapter 6 describes preservice teachers' beliefs about and perceptions of curriculum materials analysis, the reasons they give for their views, and how their beliefs and perceptions change over time. Finally, Chapter 7 includes an in-depth discussion of these findings and provides insights into theoretical frameworks on curriculum materials use, design implications for science teacher education and curriculum materials, and future research directions.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews historical and recent literature from a variety of disciplines, including science, mathematics, social studies, and language arts, on the topic of curriculum materials use. This chapter begins with a brief discussion on the historical conceptions of curriculum materials use—with a focus on science curriculum materials—and then explores in depth one theoretical perspective, which conceptualizes curriculum materials use as a participatory relationship between teacher and curriculum materials. This theoretical perspective frames this study. Within this perspective, the different components of the teacher-curriculum materials relationship and the interactions among those components are explored. The chapter then provides a detailed review of the challenges that teacher educators face in helping preservice and new teachers develop a dynamic relationship with curriculum materials. The chapter concludes with a description of the reform-based criteria intended to help beginning teachers learn about curriculum materials analysis and their connections to the knowledge base of teaching.

Historical Conceptions of Curriculum Materials Use

Several reform efforts and research studies have expressed different conceptions on what it means to use curriculum materials. For example, past reform efforts relied on curriculum materials to instigate change in schools (Welch, 1979). This view on curriculum materials use emphasized the idea that the text alone controls classroom instruction and is a fixed representation of the enacted curriculum (Remillard, 2005). Thus, this perspective viewed teachers as mere conduits of curriculum materials, suppressing their instructional autonomy and ability to critically use and design curricular resources (Clandinin & Connelly, 1991; Remillard, 2005). This “remote control” (Cohen, 2000; Shulman, 1983) or “teacher-proof” (Krajcik, Mamlok, & Hug, 2000; Rudolph, 2002) approach to curriculum materials use assumed that the ideal relationship was having the teacher enact the materials as written in order to foster fidelity to the core principles of reform initiatives (Clandinin & Connelly, 1991; Remillard, 2005). This approach assumed that fidelity was a possible and desirable goal. Therefore, curriculum materials use was understood to be the extent to which teachers followed or subverted the curricular tools.

The reform movement in the late 1950s and early 1960s emphasized this perspective on curriculum materials use (Welch, 1979). Spurred by the Soviets’ launching of Sputnik into space and the threat of the Cold War, the United States sought ways to better prepare students to become scientists. In an attempt to reform science education, the federal government funded initiatives for content experts to develop new curriculum materials for teachers to use (Lazarowitz, 2007; Welch, 1979). These science materials provided updated content, greater variety of media and materials, and increased emphasis on the processes of science. These changes attempted to increase students’ interest in and understanding of science. These curriculum materials tended to find their way into many science classrooms, thereby having a wide-spread effect on science teaching throughout the country.

While these curriculum materials were widely adopted, the curriculum materials reform efforts did little to change science instruction in schools. The primary reason these initiatives did not take hold was that the reformers failed to consider the role teachers play in shaping how materials are enacted in practice (Ball & Cohen, 1996; Berman & McLaughlin, 1978; Remillard, 2005; Sarason, 1982; Stake & Easley, 1978; Welch, 1979). In Stake and Easley's (1978) case studies of eleven schools, the researchers found that these reform efforts were largely ineffective because the curriculum developers did not anticipate the ways in which teachers might misunderstand, distort, and even undermine the materials and thus did not anticipate teachers' need to learn in order to use new materials. As a result, teachers tended to make adaptations to the materials that misrepresented the core vision of the materials while others resisted the reform efforts by returning to a more familiar yet traditional set of curriculum materials.

The results of this reform movement impacted curriculum developers' and researchers' conceptions of curriculum materials use. They realized that the teacher-proof curriculum materials of the 1950s and 1960s overlooked teachers' need to adapt their written resources in response to their own characteristics and goals, the diverse needs of their students, and the unique demands of their local contexts, thus restricting teachers' ability to improve the materials and tailor them to their personal circumstances (Brown, 2009; Barab & Luehmann, 2003, Enyedy & Goldberg, 2004; Pintó, 2004; Remillard, 2005; Squire et al., 2003). As a result, they realized that the teacher-curriculum materials relationship must account for the role of teachers (Bolin, 1987; Krajcik et al., 2000; Welch, 1979).

In attending to the role of teachers, curriculum developers and researchers began to see teachers no longer as mere conduits of curriculum materials and targets of reform but as curriculum materials makers (Clandinin & Connelly, 1991) and active agents who work with students to create the enacted curriculum (Ball & Cohen, 1996; Prawat, 1993). They began to consider teachers as curriculum developers who use written resources to design curricular plans and translate them into practice. Therefore, a new perspective on curriculum materials development began to emerge. Bolin (1987) explained:

> Curriculum development should be seen as a continuum from development of a document—which may be begun by one group—through implementation of the document by the teacher. The teacher is an active participant in the process. This participation begins with the teacher's intellectual engagement with the document, in which its substance is analyzed, modified, and supplemented in light of the realities of the teacher's own classroom. (p. 97)

Thus, this new perspective entailed viewing the curriculum materials development process no longer as stopping with curriculum developers conceptualizing and writing lesson plans for teachers but continuing into the classroom where teachers select and design curricular plans and enact those plans with students (Ben-Peretz, 1990; Bolin, 1987). Curriculum materials use became conceptualized as a process of curricular design, in which teachers critically select, critique, and adapt curriculum materials during planning and enactment (Brown, 2009; Remillard, 2005). Teachers evaluate existing resources and classroom constraints in order to develop curricular plans that enable them to achieve their instructional goals and address their students' needs (Barab & Luehmann, 2003, Pintó, 2004; Squire et al., 2003).

Theoretical Framework:

Curriculum Materials Use as Participation Between Teachers and Curriculum Materials

This study is grounded in the theoretical perspective that teachers and curriculum materials participate together in a dynamic, collaborative relationship (Brown, 2009; Lloyd, 1999; Remillard, 1999; 2000; 2005; Schneider & Krajcik, 2002; Sherin & Drake, 2009). In this participatory relationship, both the teacher and curriculum materials are active participants in the design of the planned curriculum and co-construction (with students) of the enacted curriculum (Remillard, 2005). Both teacher and curriculum materials make unique and valuable contributions to this relationship, resulting in better teaching and learning (Russell, 1997). Thus, the best learning environment is fostered by a partnership between teacher and curriculum materials.

This theoretical perspective is reminiscent of past studies describing curriculum materials use as mutual adaptation (Elmore, 1979; McLaughlin, 1976; 1990). Mutual adaptation entails the idea that teachers and curriculum materials both change through an interactive process. Innovative science curriculum materials frequently contain new pedagogical approaches to teaching science consistent with reform recommendations and thus aim to promote changes in teachers' knowledge and practice. On the other hand, teachers respond to the affordances and constraints of their local setting and thus modify materials to be responsive to their instructional goals and students' needs. Therefore, both teachers and text bring about and undergo change in the design of the planned and enacted curriculum.

Within this participatory relationship, curriculum materials serve a dual function. On the one hand, curricular resources are simply physical objects that include content and skills for students to learn, representations and phenomena for clarifying abstract ideas, and instructional approaches for guiding student learning. As such, curriculum materials are practical resources for teachers to use in planning and enacting instruction. On the other hand, drawing on socio-cultural perspectives (e.g., Cole & Engeström, 1993; Pea, 1993; Vygotsky, 1978; Cole, 1996; Wertsch, 1998), curriculum materials are also products of social activity constructed by cultural, historical, and social meanings (Brown, 2009; Wertsch, 1991). These subjective meanings shape the ideas within curriculum materials about what science is important to teach and what it means to teach science. These conceptions mediate teachers' interactions with the curriculum materials; they shape how teachers read and interpret the materials and ultimately what they learn and how they use them in practice. Therefore, these curricular tools play an active role in mediating the teacher-curriculum materials relationship by enabling and constraining teachers' curricular decision-making (Cohen & Ball, 1999; Cohen, Raudenbush, & Ball, 2002).

In addition to the ways in which curriculum materials shape the participatory relationship, teachers also, of course, serve as active participants in this partnership. As teachers read and interpret written materials, they draw upon their experiences, beliefs, knowledge, and instructional goals. These personal resources help teachers bring meaning to the materials and ultimately shape how they enact the materials in practice (Cohen & Ball, 1999; Remillard, 2005). Thus, not only do curriculum materials shape teachers' ideas and practices but teachers simultaneously shape curriculum materials as they use and adapt the materials in ways that address their own unique characteristics, needs, and goals.

This perspective that conceptualizes curriculum materials use as participation with curriculum materials has influenced a number of investigations. Most of these studies have focused their analyses on how teachers use, interpret, and adapt written resources and how the participatory relationship shapes teachers' learning and practice (Brown, 2009; Drake & Sherin, 2006, 2009; Enyedy & Goldberg, 2004; Forbes & Davis, 2007; Lloyd, 1999; Remillard, 1999; Sherin & Drake, 2009; Squire et al., 2003; Valencia et al., 2004). Two of these studies are described below in order to provide examples that illustrate how this theoretical perspective has shaped research on curriculum materials use and teacher learning.

Remillard's (1999, 2000) study of two elementary teachers' use of a newly adopted reform-oriented mathematics textbook reflects the view that curriculum materials use involves a partnership between teacher and text. This study examined teachers' interactions with the curriculum materials by describing how teachers read and selected tasks from the materials and what factors impacted their use. Findings showed that the two teachers demonstrated two different approaches to task selection. One teacher selected and enacted tasks directly from the textbook while the other teacher used the materials as a source of ideas for designing her own tasks for students. The teachers used the same materials in different ways because they attended to different parts of the textbook (e.g., student exercises versus supplementary activities) as well as read for different purposes (e.g., tasks and assignments for students versus mathematical concepts to guide planning). Differences in teachers' ideas about mathematics, teaching, and learning as well as differences in their teaching contexts contributed to dissimilar uses of the textbook, and consequently, different opportunities for student learning.

Sherin and Drake (2009, see also Drake & Sherin, 2009) also examined teachers' participation with curriculum materials in their study of ten elementary school teachers' use of reform-based mathematics curriculum materials. They examined the teachers' curricular strategies, or patterns of curriculum materials use, by describing how the teachers read, evaluated, and adapted the materials during different phases of their teaching. The researchers found that each teacher had a different pattern of curriculum materials use. The teachers tended to read for different purposes (e.g., big ideas as opposed to details), evaluate the materials with different audiences in mind (e.g., the teacher, students, administrators), and adapt materials in different ways (e.g., replace, omit, or create new tasks). The teachers also tended to engage in these curricular processes at different times—before, during, and/or after instruction. These findings highlight the idea that teachers tend to use curriculum materials in very distinct and nuanced ways.

In summary, teachers and curriculum materials are active participants in the design of instruction, impacting the partnership in unique and important ways. In this participatory relationship, teachers interpret and adapt curriculum materials in light of personal resources and needs while their meaning-making experiences with curriculum materials simultaneously prompt them to consider new ideas about the subject matter and how to teach it. These interactions influence teachers' opportunities to promote student learning as well as engage in worthwhile learning themselves.

Components of the Teacher-Curriculum Materials Relationship

Reading and learning from curriculum materials is a multi-dimensional process that is impacted by a multitude of factors pertaining to the characteristics of the text, reader, and context (Holliday, Yore, & Alvermann, 1994). Remillard (2005) created a model that captures the components of and interactions within the participatory relationship between the teacher and curriculum materials (see Figure 2.1). The components of this model include the teacher, curriculum materials, and classroom and school context. These three components interact in a variety of ways and at different points in time during the curriculum materials development process.

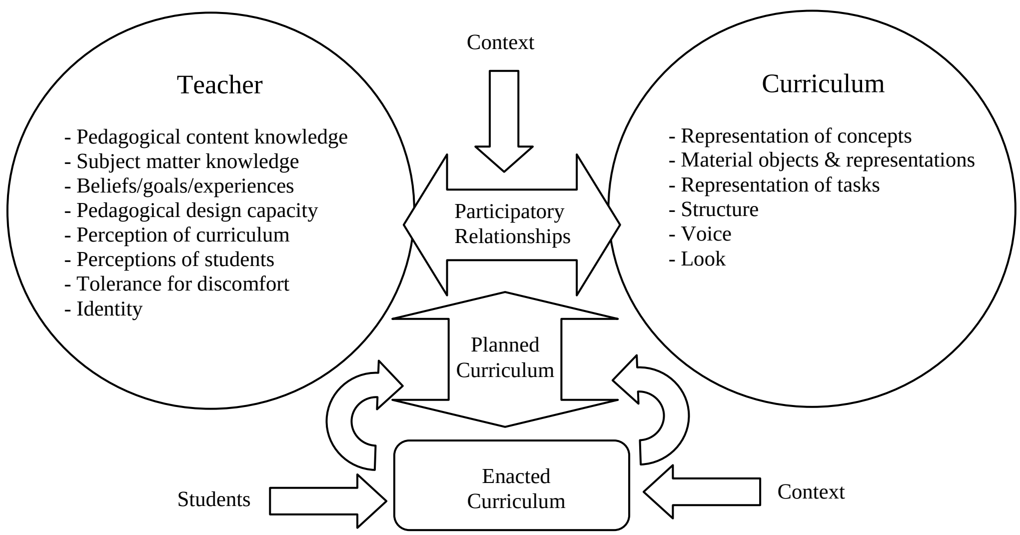

Figure 2.1. Model of the participatory relationship between teacher and curriculum materials (Remillard, 2005).

Characteristics of curriculum materials. One component of the model in Figure 2.1 is the text itself. Curriculum materials contain a variety of curricular features that shape the participatory relationship. For example, the structure of the curriculum materials—that is, the content and organization of the curricular offerings—can alleviate or exacerbate the demands of planning and enactment (Brown, 2009; Kauffman, 2002; Remillard, 2005). The structural components include the topics and organization of the subject matter as well as the tasks, activities, and readings for instruction. Brown (2009) identified three key features pertaining to the structure of curriculum materials. First, the representation of concepts is one structural feature that determines how the subject matter domain is organized and portrayed. Representations of concepts include descriptions, explanations, examples, analogies, diagrams, and models. A second feature of curricular resources is the representations of tasks. This includes the instructions for carrying out activities. These directions are sometimes targeted toward students, such as homework questions and experimental procedures, while others are directed toward teachers, such as suggestions for organizing a lesson or guidelines for facilitating a discussion. A third structural feature includes the representations of the physical objects or materials to be used during the lesson (e.g., bulbs, wires, and batteries for an electricity lesson). Curriculum materials with well-designed activities and high-quality resources dealing with content and pedagogy are likely to help teachers interact with materials in productive ways that support student learning.

A fourth structural feature described by other researchers includes educative supports embedded within curriculum materials (Ball & Cohen, 1996; Collopy, 2003; Davis & Krajcik, 2005; Heaton, 2000; Petish, 2004; Remillard, 2000; Russell, 1997; Russell, Schifter, Bastable, Yaffee, Lester, & Cohen, 1995; Schneider, 2006; Schneider & Krajcik, 2002). Educative supports are features designed to directly support teachers in learning about content, pedagogy, and student learning. Educative supports can include implementation guidance that helps teachers know *how* to use and adapt instructional approaches and activities to achieve productive instructional ends (Beyer & Davis, in press-b; Davis & Krajcik, 2005; Petish, 2004; Schneider, 2006; Schneider & Krajcik, 2002). Educative supports can also include rationales for *why* particular instructional approaches are pedagogically and scientifically appropriate (Ball & Cohen, 1996; Beyer & Davis, in press-a; Davis & Krajcik, 2005; Heaton, 2000; Remillard, 2000). Rationales provide insights into the curriculum developers' pedagogical judgments, enabling teachers to examine the assumptions underlying the instructional approaches in the curriculum materials. These educative supports have the potential to mediate teachers' interactions with curricular resources in productive ways.

In addition to these structural features, other text characteristics not directly related to the content and organization of the curriculum materials can also enable or constrain teacher-curriculum materials interactions. These characteristics have more subtle and often unintended influences on these interactions. For example, 'the look' of the materials can influence how flexibly teachers view the materials. A complete and finished look may give curriculum materials a sense of authority that leads teachers to struggle with adapting the materials (Lloyd, 1999; Love & Pimm, 1996). Lloyd (1999) found in her investigation of two secondary teachers' use of reform-oriented mathematics curriculum materials that even though the teachers had concerns with the materials, they did not adapt them to better suit their personal goals and needs. The teachers used the materials as-is because they saw the materials as a form of constraint. They felt restricted in their ability to personalize their teaching because the reform-oriented materials had accomplished much of the decision-making about the design of instruction. Researchers have argued that curriculum materials that build in more "space" for teachers to make curricular decisions can help deemphasize this sense of authority that teachers perceive (Bridgham, 1971; Remillard, 2000). This space may provide teachers with the much-needed flexibility to do their work.

A final characteristic of curriculum materials is its voice, that is, how the curriculum developers talk to the teacher and represent themselves in the text (Remillard, 2005; Schneider, 2006). Designers often downplay their presence by avoiding the use of first-person pronouns in the text (Love & Pimm, 1996; Remillard, 2002). The absence of these pronouns conceals the rationales behind the designers' pedagogical judgments and curricular decisions. Instead, many texts use second-person pronouns to communicate to teachers. This voice tends to perpetuate the authoritative presence of the materials.

Teacher characteristics. Another component of Remillard's (2005) model is the teacher and the personal resources he or she draws upon to make sense of the offerings provided in a set of curriculum materials. These resources enable or constrain the ways in which teachers collaborate with written materials.

First, teachers' interactions with curriculum materials are mediated by their knowledge and beliefs about the subject matter, teaching, and learning (Brown, 2009; Collopy, 2003; Enyedy & Goldberg, 2004; Forbes & Davis, 2007; Kauffman, 2002; Olson, 1981; Pintó, 2004; Remillard, 1999; 2000; Sosniak & Stodolsky, 1993; Squire et al., 2003). These personal resources shape what teachers understand from reading the curriculum materials and how they enact the materials with students. Specifically, the extent to which teachers' knowledge and beliefs are aligned with reform recommendations has important implications for how they participate with reform-based curriculum materials (Collopy, 2003; Cronin-Jones, 1991; Enyedy & Goldberg, 2004; Kauffman, 2002; Olson, 1981; Petish, 2004; Remillard, 1999; Schneider & Krajcik, 2002; Squire et al., 2003). For example, teachers who express compatible knowledge and beliefs tend to use their materials in ways that support reform initiatives and are afforded opportunities to learn from their materials. In contrast, teachers displaying traditional views of teaching and learning tend to adapt materials in ways that result in “lethal mutations,” thus failing to perceive and enact curriculum materials in ways that support reform efforts (Brown & Campione, 1996).

For example, the two elementary teachers in Remillard’s (1999) study, described above, conveyed divergent ideas about the nature of mathematics and how it is learned. One teacher viewed mathematics as a set of formulas and rules and believed that student learning occurred through drill and practice of computational skills. The other teacher viewed mathematics as a body of interconnected concepts and believed that students learn through inventing and sharing solutions to problems. The differences in their beliefs about mathematics and learning shaped what they read in the curriculum materials and for what purposes. As a result, “differences in their reading led to differential opportunities for teacher learning” (p. 333). In these ways, teachers’ knowledge and beliefs about the subject matter and pedagogy shape their interactions with curriculum materials and thus impact opportunities for student learning as well as the opportunities they have to learn with and from the materials.

Second, teachers’ orientations toward curriculum materials also promote or constrain their use of curricular guides. This orientation includes teachers’ disposition toward their particular set of curriculum materials and their stance toward curricular resources, in general (Remillard & Bryans, 2004; Remillard & Rhude-Faust, 2006). Some teachers exhibit orientations that allow them to see curriculum materials as resources for their own learning, while other teachers merely view curriculum materials as resources from which to draw activities and tasks for students (Collopy, 2003; Kauffman, 2002;

Remillard, 1999; Remillard & Bryans, 2004). To better understand the impact of teachers' orientations toward curriculum materials, Remillard and Bryans (2004) investigated eight elementary teachers' use of reform-oriented mathematics curriculum materials over a two-year period. The researchers found that the teachers' stances toward curriculum materials in general and their perceptions of their own set of curriculum materials had a greater impact on how they used the materials than the extent to which the materials aligned with their own knowledge and beliefs about mathematics, teaching, and learning. For example, two of the teacher participants expressed skeptical stances toward their materials and used them in similar ways—intermittently and narrowly—despite having very different ideas about the subject matter and how to teach it.

Teachers' professional identity is a third characteristic that shapes curriculum materials use and opportunities for learning from curriculum materials. Identity is the "constellation of interconnected beliefs and knowledge about subject matter, teaching, and learning as well as personal self-efficacy and orientation toward work and change" (Collopy, 2003, p. 289; see also Drake, 2006; Drake, Spillane, & Hufferd-Ackles, 2001; Drake & Sherin, 2006; Forbes & Davis, 2008; Spillane, 2000). Collopy's (2003) analysis of two elementary teachers' use of newly adopted reform-oriented mathematics curriculum materials provides an illustrative example of the role of identity in shaping teachers' interactions with curricular resources. The two teachers in this study had very different identities, resulting in different engagements with and learning from the materials. One teacher was not comfortable with her knowledge of mathematics but had an identity as a teacher and learner that was compatible with the underlying philosophy of the curriculum materials. As a result, this teacher followed the structure of the lesson plans and used the problems and activities as suggested in the materials, embracing the materials to support her own learning about mathematics and pedagogy. In contrast, the other teacher expressed a high level of mathematical self-efficacy and had beliefs integral to her identity that conflicted with the beliefs targeted by the curriculum materials. Consequently, this teacher did not view the materials as relevant for promoting her own learning. Instead, she greatly modified the reform-oriented materials and eventually returned to a more traditional textbook.

A final teacher characteristic that shapes the participatory relationship is teachers' pedagogical design capacity. This characteristic is of particular interest in this study. This capacity entails the "ability to perceive and mobilize existing resources in order to craft instructional contexts" (Brown, 2009, p. 24). The resources that teachers mobilize include the curricular features and teacher characteristics described above. Teachers' pedagogical design capacity is not just a function of having particular types of knowledge and beliefs. It also includes the ability to act upon these personal resources while interacting with particular material resources in order to design powerful learning opportunities for students (Cohen & Ball, 1999; Remillard, 2005). Thus, in exercising their pedagogical design capacity, effective teachers negotiate the affordances and constraints of curricular features while taking into consideration their own understandings, instructional goals, and classroom needs.

Context. The third component of Remillard's (2005) model of the teacher-curriculum materials relationship shown in Figure 2.1 is the classroom and school context. Many contextual factors mediate how teachers design and enact curricular plans. For example, students vary from classroom to classroom, bringing with them a unique set of ideas, experiences, dispositions, and resources that shape what and how they learn. Teachers' perceptions of their students' needs influence how they draw on students' experiences and resources as they teach (Collopy, 2003; Remillard, 2000; Sherin & Drake, 2009; Wilson & Lloyd, 2000). Classroom and institutional constraints also shape curriculum materials use and enactment (Enyedy & Goldberg, 2004; Forbes & Davis, 2007; Kauffman, 2002; Lloyd, 1999; Pintó, 2004; Remillard, 1999; Sosniak & Stodolsky, 1993; Spillane et al., 2001; Squire et al., 2003). Policy guidelines, local curriculum frameworks, parental views, and administrative and departmental expectations affect teachers' perceptions of the level of flexibility they have in designing learning environments.

The role of contextual constraints in the teacher-curriculum materials relationship is illustrated in Kauffman's (2002) investigation of four beginning elementary teachers and their enactment of curriculum materials. The study found that the teachers varied in the degree of agency permitted by their school district and consequently differed in the amount of support they received from their curriculum materials. Some school districts created an environment that allowed teachers to decide what and how to teach and thus enabled the teachers to benefit from the support of their curriculum materials. On the other hand, other school districts deterred teachers from using the available curricular resources and instead encouraged them to seek out other resources. In these ways, the classroom culture and surrounding community context influence teachers' sense of agency in mobilizing curricular resources.

Summary. The teacher and curriculum materials are integral components of the participatory relationship. Teachers bring a complex constellation of dispositions, perspectives, beliefs, knowledge, and abilities that shape their interactions with text. Likewise, curriculum materials contain a variety of structural, visual, and textual features that contribute to this collaborative partnership. Additionally, both the teacher and the curriculum materials are in dynamic interaction with the local classroom and school contexts. This network of interactions among teacher, text, and context results in unique patterns of curriculum materials use and consequently differential opportunities for teacher and student learning.

Interactions Among the Components in the Teacher-Curriculum Materials Relationship

Several researchers have developed models and frameworks to describe the interactions among the components in the participatory relationship (e.g., Brown, 2009; Drake & Sherin, 2009; Remillard, 1999). These constructions shed light on how teachers participate with curriculum materials and when these interactions take place. To begin, this section uses Remillard's (1999) model of the curriculum materials development process to describe three important arenas *when* teachers use curricular resources. Subsequently, Sherin and Drake's (2009; see also Drake & Sherin, 2009) framework and Brown's (2009) model of teacher's curriculum materials use are described, along with findings from other research studies, to explore *how* teachers collaborate with materials during the different arenas of curriculum materials use.

When teachers participate with curriculum materials. Remillard's (1999) model of the curriculum materials development process includes three arenas that capture the times in which teachers engage with and enact curricular resources (see Figure 2.2). First, the curriculum mapping arena is the space where teachers make decisions about how to use curriculum materials to plan the content, sequence, and pace of instruction. A coherent set of curriculum materials often illustrates one perspective on what topics to teach, how to structure them, and how long to spend on each topic. A number of research studies have found that teachers typically vary in how they use this information from the materials (Freeman & Porter, 1989; Kauffman, 2002; Nicol & Crespo, 2006; Remillard & Bryans, 2004). Some teachers adhere to the materials, following the materials closely to guide their own teaching and learning. Other teachers adapt and supplement the materials. These teachers use the materials to guide the overall content and structure of the curriculum materials but modify and elaborate upon the activities and tasks in order to craft the learning environment toward their own personal goals, strengths, and needs. Still other teachers veer from the sequence of the materials and instead create their own curricular map using a variety of curricular resources as well as their own experiences and ideas about the subject matter and how it should be taught. As a result, these teachers intermittently and narrowly use a particular set of curriculum materials.

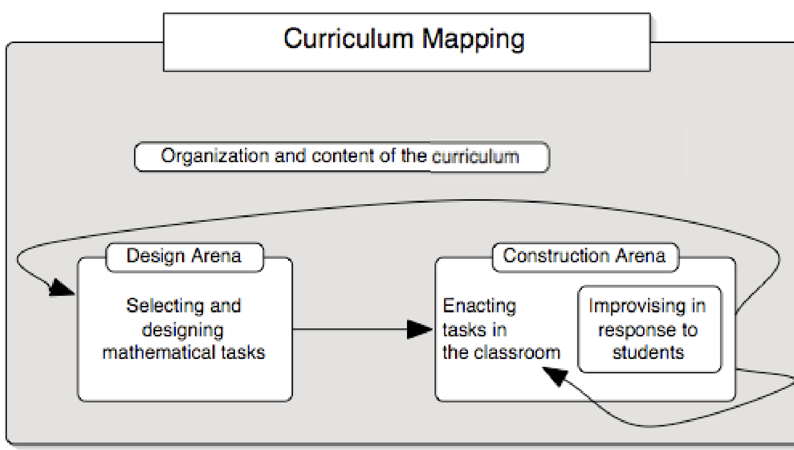

Figure 2.2. Model demonstrating when teachers use curriculum materials during the development process (Remillard, 1999).

The activities of both the design arena and the construction arena are embedded within the context of the mapping arena and primarily pertain to the day-to-day decisions that a teacher makes about how to use the curriculum materials as opposed to the overall decision about whether to follow a set of materials or to veer from it. The activities of the design arena typically occur before instruction as teachers plan with a set of curriculum materials. During planning, “the curriculum materials shape what teachers seek, read, and draw on in the curriculum resource while the teacher selects, adapts, and changes the resource” (Remillard, 1999, p. 338). These participatory interactions produce the planned curriculum, that is, the teacher’s curricular plans for what content to teach and how to teach it (Remillard, 2005). How preservice teachers interact with curriculum materials to produce the planned curriculum is the area of focus of this dissertation.

Following the design arena is the construction arena where teachers enact their intended plans while making on-the-spot decisions in response to students’ encounters with the tasks. The actual events that teachers and students experience in the classroom result in the enacted, or implemented, curriculum (Ball & Cohen, 1996; Clandinin & Connelly, 1991). The enacted curriculum captures the teacher’s plans as they are translated into practice through interactions with learners in particular contexts. Therefore, teachers, students, and materials play a role in constructing the enacted curriculum (Cohen & Ball, 1999; Cohen et al., 2002).

How teachers participate with curriculum materials. The frameworks constructed by Sherin and Drake (2009; see also Drake & Sherin, 2009) and Brown (2009) shed light on the ways in which teachers and curriculum materials interact. These forms of participation provide insights into the types of activities that teachers engage in during the design and construction arenas.

First, teachers participate with materials by reading and interpreting the text (Ben-Peretz, 1990; Drake & Sherin, 2006, 2009; Remillard, 1999; 2000; Remillard & Bryans, 2004; Schneider & Krajcik, 2002; Sherin & Drake, 2009). Teachers read through curricular offerings in order to understand what is in the text. Because teachers exhibit different personal characteristics, teachers draw on different resources to guide their decisions about what to pay attention to and how to make sense of what they read. For example, in their study of three middle school teachers' use of science curriculum materials, Schneider and Krajcik (2002) found that teachers read different parts of the materials and read for different purposes. Two of the teachers read the entire set of materials and focused their reading on how students would respond to each lesson. In contrast, the third teacher tended to read only the student worksheets and focused on what students would need to complete for each lesson.

In addition to reading and interpreting lessons, teachers also critique curriculum materials for use during instruction (Ben-Peretz, 1990; Drake & Sherin, 2006, 2009; Sherin & Drake, 2009; Sosniak & Stodolsky, 1993). In their evaluations, teachers assess the strengths and weaknesses of the subject matter, its organization and pace, and the pedagogical strategies for helping students learn about the content. Teachers often make these assessments in light of particular considerations or criteria (Drake & Sherin, 2006, 2009; Mulholland & Wallace, 2005; Sherin & Drake, 2009). The use of criteria to guide preservice teachers' analysis of curriculum materials is of particular interest in this dissertation. Such criteria may be based on reform-based standards, teachers' own instructional goals, specific students' needs, and contextual constraints. For example, Sherin and Drake (2009) found that teachers tended to examine curriculum materials in light of particular audiences, such as teachers, students, parents, and administrators. In thinking about their students, teachers examined lesson plans in terms of whether or not the materials would promote student learning, and with regard to themselves as teachers, they examined the curriculum materials in terms of their ability to facilitate students' understanding of the subject matter.

After critiquing activities presented in curriculum materials, teachers then decide how to use the materials (Brown, 2009; Drake & Sherin, 2006; Remillard, 1999; Schneider & Krajcik, 2002). One way teachers use materials is to appropriate tasks directly from the curricular resources and use them as-is with students (Remillard, 1999). This approach shifts the responsibility of designing the planned curriculum to the materials—a strategy referred to as curriculum offloading (Brown, 2009). Teachers sometimes rely heavily on materials to design instruction because they are unfamiliar or uncomfortable with the subject matter and how to teach it.

A second way that teachers use curricular resources after reading and critiquing them is to redesign tasks and activities from their original format (Brown, 2009; Remillard, 1999). This approach entails adopting some components of lesson plans while modifying others, resulting in a shared responsibility between the teacher and text in designing the planned curriculum. Teachers adapt materials in a number of ways (Drake & Sherin, 2006, 2009; Sherin & Drake, 2009). At an activity-level, teachers create new lessons, replace or substitute one lesson for another, or omit lessons altogether. Within activities, teachers change activity sequences, the materials used, student or teacher control over an activity, participant structures, the time allocated to an activity, and experimental procedures and problems. Teachers decide how to adapt lessons based on a variety of reasons (Brown, 2009). Some modify curricular plans in order to suit their own personal teaching style, target crucial standards, and work within particular classroom and institutional constraints. Additionally, as student populations become increasingly diverse, teachers need to adapt lessons in order to address particular student needs, help students see connections between content ideas and their everyday lives, and engage students in tasks that are personally meaningful to them.

Third, after reading and identifying the strengths and weaknesses of materials, teachers sometimes decide not to appropriate or adapt lesson activities but instead decide to use the materials as a source of inspiration for inventing their own tasks (Brown, 2009; Remillard, 1999). In implementing this curricular strategy, teachers carry the primary responsibility for the design of the curriculum materials while the written materials serve only as a resource for generating ideas. Teachers tend to create their own lessons if they are equipped with the knowledge and skills needed to fully rely on their own design initiatives. Another reason that teachers sometimes carve out their own instructional path is to take advantage of learning opportunities for students during classroom situations.

Summary. Teachers interact with curriculum materials in a variety of ways in designing the planned and enacted curriculum. Teachers read, interpret, and critique materials and subsequently appropriate, adapt, or improvise curricular tasks. These curricular practices result from the dynamic relationship between the personal resources of teachers and the curricular features of texts as teachers use curriculum materials with students in particular contexts.

Challenges to Developing Beginning Teachers' Pedagogical Design Capacity

In order to critique and adapt lesson plans in designing the planned curriculum, teachers need to develop their pedagogical design capacity for analyzing curriculum materials. However, developing this capacity is no easy task. This is especially true for preservice and new teachers, who face a unique set of challenges in learning how to use curriculum materials in productive ways. These challenges are explored below and illustrated with findings from the literature.

Developing Curricular Plans From Scratch

Some preservice teachers develop the idea from their teacher education coursework that good teachers are creative and imaginative and thus develop their lesson plans from scratch (Ball & Feiman-Nemser, 1988; Goodman, 2002; Nicol & Crespo, 2006). Preservice teachers come to believe that these teachers use curriculum materials only as a source of ideas for designing their own curriculum materials. For example, Ball and Feiman-Nemser (1988) found that two science methods courses at two different institutions led preservice elementary teachers to develop the belief that their own ideas about the subject matter and how to teach it were a better resource for designing instruction than existing written materials. Thus, the methods courses did not support preservice teachers in seeing how curriculum materials could play a constructive role in the design of the planned curriculum and thus did not prepare them to use curriculum materials in productive ways when they entered their student teaching semester.

Adhering to Curriculum Materials

Other preservice and new teachers are avid consumers of curricular resources. They use curriculum materials as written, even when they are aware of their limitations.

Beginning teachers develop an uncritical stance toward curriculum materials for a variety of reasons. One reason is because they may not have had the opportunity to develop different aspects of their knowledge base essential for modifying materials (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Remillard & Bryans, 2004; Valencia et al., 2006). For example, many beginning teachers have not had the teaching experiences needed to help them develop their pedagogical content knowledge (Abell & Roth, 1992; Davis, Petish, & Smithey, 2006; Lederman, Gess-Newsome, & Latz, 1994; van Driel, Verloop, & de Vos, 1998), that is, the knowledge that teachers use to help their students develop a deep understanding of specific subject matter (Shulman, 1986). Beginning teachers also tend to have weak understandings of the subject matter and less confidence in their subject matter knowledge (Cochran & Jones, 1998; Davis et al., 2006). For example, in Grossman and Thompson's (2004) study of three secondary English teachers, they found that these teachers tended to follow the curriculum materials as written during their first year of teaching because they felt like they did not have sufficient knowledge about the subject matter and how to teach it in order to compensate for the materials' limitations.

A second reason beginning teachers may latch onto curriculum materials uncritically is to negotiate the high demands of teaching (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Powell, 1997). In addition to dealing with the day-to-day responsibilities of a being a new teacher, beginning *elementary* teachers specifically have to teach concepts from multiple science disciplines and teach several other subjects in addition to science (Abell, Bryan, & Anderson, 1998; Anderson & Mitchener, 1994; Cochran & Jones, 1998; Weiss, Banilower, McMahon, & Smith, 2001; Zembal-Saul, Krajcik, & Blumenfeld, 2002). Thus, beginning teachers may benefit from the concrete guidance provided by curriculum materials. For example, in Powell's (1997) study of two beginning science teachers, both teachers believed that instruction should not rely exclusively on the textbook. However, they both made the textbook central to instruction in order to address classroom uncertainties and frustrations. In these ways, teachers may choose to receive support from their curriculum materials about what content to teach and how to teach it rather than to modify them to take into account their beliefs, goals, and needs.

Third, published curriculum materials may communicate a sense of authority, leading some beginning teachers to see curriculum developers as more knowledgeable than themselves about the subject matter and how to teach it. As a result, these teachers may view adaptation of curriculum materials as a destabilizing experience and thus follow curriculum materials as-is (Ben-Peretz, 1990; Bullough, 1992; Schwarz et al., 2008; Valencia et al., 2006). For example, one new elementary teacher explained that she did not modify her materials because she felt that it was "presumptuous of [her] to question such a well-researched, proven program" (Valencia et al., 2006, p. 103). The authority of curriculum materials may thus constrain teachers' efforts to make adaptations in order to address their students' needs and their own goals and strengths.

A fourth reason why some beginning teachers do not critically analyze curriculum materials is that they may not have had the opportunity to see curriculum materials analysis as an authentic teaching task (Bullough, 1992; Haney & McArthur, 2002; Nicol & Crespo, 2006; Schwarz et al., 2008). As a result, they may develop the belief that the design of the planned curriculum is the sole task of curriculum developers. For example, Nicol and Crespo's (2006) analysis of preservice elementary teachers' use of curriculum materials revealed that the preservice teachers engaged with and enacted the materials in a variety of ways, ranging from adherence to adaptation to invention of materials. One crucial factor impacting whether the preservice teachers viewed curriculum materials as an adaptive resource was whether they perceived their cooperating teachers to be flexible users of the curriculum materials. The preservice teachers were less likely to adapt and elaborate upon their curricular offerings if they perceived that their mentors exclusively relied on curriculum materials to decide what and how to teach.

Finally, preservice and new teachers may not critique and adapt their curriculum materials if they perceive that they do not have supportive curricular contexts. For example, teachers may have limited access to curricular resources (Appleton & Kindt, 2002; Ball & Feiman-Nemser, 1988; Nicol & Crespo, 2006; Valencia et al., 2006); this is especially true for elementary science teachers (Kauffman et al., 2002). Other teachers may have little curricular agency afforded to them by their cooperating teacher, department, or school district (Kauffman, 2002; Lloyd, 1999; Schwarz et al., 2008; Valencia et al., 2006). Expectations that teachers will uniformly implement a coherent set of curriculum materials constrain what and how they are able to teach. For example, in Valencia and colleagues' (2006) longitudinal study, four beginning elementary teachers varied greatly in their access to curriculum materials for reading and in the flexibility of their curricular contexts. Teachers with comprehensive and highly structured curricular programs mandated by their school districts and few additional resources were the least able to modify the curriculum materials for instruction. As a result, these teachers tended to use the materials in a prescriptive manner, leading to a focus on the completion of tasks and activities rather than on student learning.

Critiquing and Adapting Curriculum Materials

In contrast to inventing their own activities or following curriculum materials as-is, some beginning teachers are able to critique and adapt written materials when provided with support. With regard to their critiques, many beginning teachers are able to apply criteria in their assessment of curriculum materials (Davis, 2006; Schwarz et al., 2008). However, their initial ideas about criteria tend to focus on the practical and affective aspects of teaching (Bullough, 1992; Lloyd & Behm, 2005; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Schwarz et al., 2008; Southerland & Gess-Newsome, 1999). For example, Schwarz and colleagues (2008) found that the preservice elementary teachers in their science methods courses tended to focus on the explicitness and feasibility of procedures, the presence of explanations for students, the helpfulness of the teacher background information, and the extent to which activities are fun, hands-on, and connected to students' lives. These criteria address important concerns dealing with the high demands of teaching but do not represent more complex ideas about teaching.

With regard to their adaptations, many beginning teachers may not have clear ideas about how to address the weaknesses they find in curriculum materials. Without support, some may choose not to adapt the materials (Lloyd & Behm, 2005; Valencia et al., 2006) or may only make superficial changes that do not address significant weaknesses (Grossman & Thompson, 2004; Nicol & Crespo, 2006). Still other teachers may modify materials in ways that distort the intent of the original materials (Ball & Feiman-Nemser, 1988; Enyedy & Goldberg, 2004; Pintó, 2004; Squire et al., 2003).

Summary

Beginning teachers encounter many challenges in developing their pedagogical design capacity for analyzing curriculum materials. Some teachers develop lesson plans from scratch because they have been taught that good teachers do not rely on curriculum materials. Alternatively, other beginning teachers follow curriculum materials verbatim, adopting an uncritical stance toward curriculum materials. Still others critique and adapt curriculum materials but in unproductive ways. Thus, preservice and new teachers need scaffolded opportunities to overcome these challenges in order to develop their pedagogical design capacity.

Purpose of the Study

Exploring the Use of Reform-Based Criteria to Scaffold the Development of Pedagogical Design Capacity

To help preservice teachers develop a principled, reform-oriented perspective on the analysis of science curriculum materials, I used a set of well-specified, standards-based criteria as scaffolds. These criteria were based upon current science education research about how students can best be supported in learning about science. Scaffolds are supports that enable learners to complete more difficult tasks that they would be unable to do on their own, and in turn, achieve higher levels of understanding (Wood, Bruner, & Ross, 1976; see also Hogan & Pressley, 1997; Stone, 1993; Tabak, 2004). The reform-based criteria used in this study were based on the AAAS Project 2061 Instructional Analysis Criteria (Kesidou & Roseman, 2002; Stern & Roseman, 2004). (The Project 2061 curriculum-materials analysis procedure is based on existing research on student learning and is currently used at the national level to analyze science curriculum materials.) These criteria also addressed topics commonly taught in science methods courses (Davis, 2006; NRC, 1996; Schwarz et al., 2008; Smith, 2000). These criteria represented complex ideas related to the teaching and learning of science that were likely to need more unpacking and elaboration than other analysis criteria representing less complex ideas. The seven criteria included (1) attending to learning goals, (2) establishing a purpose, (3) eliciting students' initial ideas and predictions, (4) providing experiences with phenomena, (5) promoting students' sense-making, (6) assessing student learning, and (7) making science accessible for all students. Table 2.1 lists the seven analysis criteria along with a brief description of each criterion.

Table 2.1
Overview of Reform-Based Criteria Used in the Science Methods Course

	Criterion	Description
1	Attending to learning goals	Considers whether learning goals address both science content and inquiry and are aligned with standards and the lesson activities.
2	Establishing a purpose	Considers whether the materials explicitly present a contextualized and meaningful driving question or problem.
3	Eliciting students' initial ideas and predictions	Considers whether the materials provide teachers with questions or tasks for identifying and probing beneath students' responses.
4	Providing experiences with phenomena	Considers whether the materials provide multiple and varied experiences with phenomena and opportunities to record data.
5	Promoting students' sense-making	Considers whether the materials provide students with opportunities to explore, explain, and revise their ideas.
6	Assessing student learning	Considers whether assessments focus on understanding of key ideas and provide opportunities for each student to express ideas.
7	Making science accessible for all students	Considers whether the materials create a welcoming classroom community that enables all students to experience success and that provides all students with a feeling of belonging.

By scaffolding the preservice teachers' use of these criteria, I aimed to develop their understanding of the components of reform-based, inquiry-oriented science teaching—as foregrounded in the criteria. In turn, I hoped to develop the preservice teachers' pedagogical design capacity for analyzing science curriculum materials in planning for instruction—specifically, their ability to recognize the strengths and weaknesses of materials and make beneficial adaptations.

Grounding Criteria in a Model of Pedagogical Content Knowledge for Science Teaching

Model of pedagogical content knowledge for science teaching. I grounded the reform-based criteria in the knowledge base of teaching—specifically, within the construct of pedagogical content knowledge (PCK) for science teaching. PCK is the knowledge that teachers use to help their students develop a deep understanding of specific subject matter (Shulman, 1986). This unique subject-specific body of knowledge results from an interaction among their general pedagogical knowledge, knowledge of context, and subject matter knowledge (Grossman, 1990). This personal resource mediates teachers' interactions with curriculum materials as they engage in curricular planning and thus impacts opportunities for student learning as well as opportunities teachers have to learn with and from the materials themselves.

PCK entails several knowledge components that work together to help teachers represent specific subject matter in a way that makes it comprehensible to students. Magnusson, Krajcik, and Borko (1999) created a model that specifies five different components of PCK for *science* teaching (see Figure 2.3). This model has formed the theoretical basis for much research on PCK for science teaching (see Abell, 2007 for her use of the model in organizing the research on science teacher knowledge). Magnusson and colleagues (1999) identified five components of the model, which they defined as: (a) orientations toward science teaching, which include an understanding of the purposes for and general approaches to teaching science; (b) knowledge of students' understanding of science, which includes an understanding of the prerequisite knowledge that students need and the difficulties that students typically face when learning scientific subject matter; (c) knowledge of science curricula; (d) knowledge of science instructional strategies; and (e) knowledge of science assessment. The latter three dimensions are particularly relevant to this study and are elaborated in detail below.

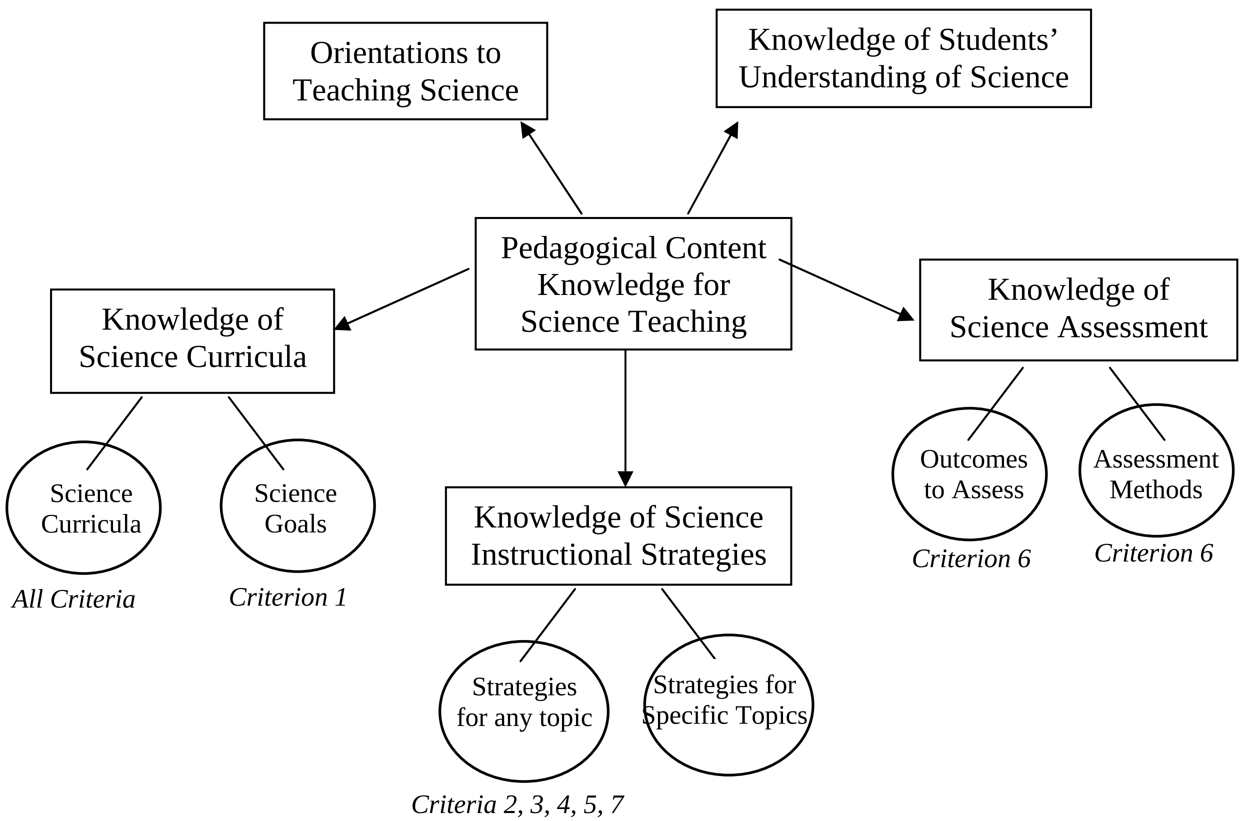

Figure 2.3. Model of pedagogical content knowledge for science teaching (modified from Magnusson, Krajcik, and Borko, 1999 and Abell, 2007) and connections made to reform-based criteria used in the science methods course (in gray).

Knowledge of science curricula is one component of PCK for science teaching. Magnusson and colleagues (1999) identified two main dimensions of this component: knowledge of science goals and specific science curricula. Knowledge of science goals and objectives includes understanding what the key learning goals are for a particular topic as well as how these goals connect across different topics during the school year. Teachers determine these short-term and year-long goals by taking into consideration students' prior knowledge and alternative ideas, the big ideas that are fundamental to the discipline, and the learning goals mandated by district, state, and national standards. The other dimension, knowledge of specific science curricula, includes an understanding of the specific curricular programs within science that are available for teaching particular topics. This includes knowledge of the general learning goals and activities within these programs. By knowing what programs and materials are available, teachers are able to make informed decisions about what resources to use with students.

PCK for science teaching also includes a repertoire of instructional strategies for teaching science. Knowledge of science instructional strategies includes two components: an understanding of science-specific strategies for teaching science, in general, and for teaching science topics, specifically (Magnusson et al., 1999). This understanding includes not only knowing about these instructional strategies but also how to use them and for what purposes. Science-specific strategies for any topic include such examples as eliciting students' initial ideas about the content at the beginning of a lesson and promoting students' thinking about their experiences with phenomena. On the other hand, strategies for specific science topics include use of topic-specific instructional representations (e.g., examples, models, analogies) and activities (e.g., problems, demonstrations, simulations, investigations, experiments). These particular strategies can help teachers represent or clarify science-specific topics for students.

One final component of PCK for science teaching is knowledge of science assessment. Magnusson and colleagues (1999) defined this component as the knowledge that teachers have about what outcomes to assess in science and how to assess those outcomes. Important dimensions of science learning to assess include students' understanding of key science concepts as well as their understanding and abilities necessary to engage in scientific inquiry. Teachers know what counts as evidence of what students have learned and align their assessments with learning goals. Additionally, teachers are familiar with different methods for assessing student learning and when they are appropriate to use. Examples of different kinds of assessments include observations, dialogue, tests, quizzes, performance-based assessments, portfolios, journal entries, lab reports, drawings, and other student artifacts. Knowing what methods to use for assessment helps teachers uncover their students' understanding of science and know how to further build upon their students' ideas to help them learn the subject matter.

Building upon Magnusson and colleagues' (1999) model of PCK for teaching science topics, other researchers have further specified that teachers also need PCK for teaching about scientific inquiry (Davis & Krajcik, 2005; Zembal-Saul & Dana, 2000). This type of knowledge is important for helping students develop their understandings about and abilities necessary to engage in scientific inquiry. PCK for scientific inquiry entails an understanding of the instructional strategies for supporting students in asking and answering scientific questions, experiencing multiple and varied phenomena, collecting and analyzing data, and developing and communicating evidence-based explanations (NRC, 2000). It also includes knowledge of students' ideas about scientific inquiry, science curricula with an inquiry approach, strategies for assessing students' inquiry abilities and understandings, and orientations to scientific inquiry.

In summary, teachers need to develop a wealth of knowledge in order to promote students' learning not only of science topics but also of scientific inquiry.

Connections between PCK for science teaching and reform-based criteria. Understanding the pedagogical ideas underlying the reform-based criteria used in the science methods course required that the preservice teachers develop particular aspects of their PCK for science teaching. The ideas foregrounded in the reform-based criteria overlapped in particular ways with the different components of this knowledge domain. Some of the criteria directly mapped onto the definitions of the knowledge components of PCK initially described by Magnusson and colleagues (1999) whereas the knowledge underlying successful application of other criteria required that the definitions of some of the knowledge components be broadened. The connections between the criteria and the components of PCK for science teaching are highlighted in Figure 2.3 (above) and described in detail below.

Criterion 6—'assessing student learning'—was intended to foster preservice teachers' knowledge of science assessment, including their understanding of assessment outcomes and methods. In applying criterion 6, teachers must understand the different dimensions of student learning that are important to assess, which include not only students' science content knowledge but also their inquiry abilities and understandings. Additionally, teachers must have knowledge of different methods for assessment. Magnusson and colleagues (1999) defined this dimension in terms of understanding what the different methods for assessing student learning are (e.g., written tests, journal entries, portfolios) and when they are appropriate to use. Being able to apply criterion 6 includes this type of knowledge with additional specificity to its description. As teachers decide which methods are appropriate, they must consider whether the assessment method enables them to assess *each* student with regard to their learning goals and whether it enables students to apply their ideas to a new task or situation.

Criteria 2—'establishing a purpose,' 3—'eliciting students' initial ideas and predictions,' 4—'providing experiences with phenomena,' 5—promoting students' sense-making,' and 7—'making science accessible to all students'—aimed to promote preservice teachers' knowledge of science instructional strategies—specifically, their understanding of subject-specific strategies for any topic. Magnusson and colleagues (1999) defined these types of strategies as the general approaches to teaching science. Being able to apply these criteria requires this kind of knowledge with additional specificity. In applying the criteria, teachers must have knowledge of instructional strategies for supporting not only students' understanding of science but also students' understandings of and abilities for engaging in scientific inquiry (Davis & Krajcik, 2005; Zembal-Saul & Dana; 2000). For example, teachers can help students learn about science topics by developing their knowledge of instructional strategies for establishing the purpose of a lesson (criterion 2) and eliciting students' initial ideas about the content (criterion 3). On the other hand, teachers can help students engage in scientific inquiry by developing their knowledge of instructional strategies for supporting students in making predictions (criterion 3), engaging in scientific phenomena (criterion 4), collecting and analyzing data (criterion 4), and developing evidence-based explanations (criterion 5). Additionally, being able to apply the above criteria requires an understanding of not only the types of instructional strategies for enacting science instruction but also the ways in which teachers can successfully enact the strategies in practice. For example, for criterion

2, teachers must have strategies that not only make the purpose of the lesson explicit to students but that also help students see the lesson purpose as connected to previous lessons and meaningful to their own lives. Additionally, for criterion 3, teachers must have strategies that not only uncover students' initial ideas and predictions but that also elicit explanations and provide opportunities for students to record and share these ideas.

Criterion 1—'attending to learning goals'—aimed to develop preservice teachers' knowledge of science curricula, and specifically, their understanding of science goals and objectives. Magnusson and colleagues (1999) described this dimension of curricular knowledge as having an understanding of national-, state-, or district-level curriculum frameworks, which specify the learning goals for students in the subjects that teachers are teaching. Being able to apply criterion 1 requires that teachers have this kind of knowledge so that they can determine if the learning goals within their lesson plans are grade-appropriate, aligned with standards documents, and address both content and inquiry standards. However, the application of criterion 1 also requires that teachers understand that learning goals need to be aligned with lesson activities and assessments. This additional understanding broadens the initial description proposed for knowledge of science learning goals.

Finally, the set of criteria, taken as a whole, was intended to help preservice teachers develop their knowledge of science curricula. One dimension of this knowledge component described by Magnusson and colleagues (1999) included having familiarity with the science curricular programs available to teachers. I expanded this description to include knowledge not only about the types of curriculum materials but also about the fruitful ways in which they can be used in designing instruction for students. In this study, this specifically meant developing an understanding of productive analysis strategies, including knowing about a criterion-based approach to analysis and about the use of reform-based criteria, specifically. Therefore, being able to apply the set of criteria entailed an understanding of the ways in which teachers can use curriculum materials to promote student learning.

Conclusions

It is important that beginning teachers use existing curriculum materials. Curricular resources can help beginning teachers negotiate the complexities of teaching. Being open to the guidance of published curriculum materials can also promote their learning about the subject matter and help them think pedagogically about particular content. Curriculum materials can also serve as a scaffold for new learning by providing teachers with opportunities to test new ideas and strategies and reflect upon these experiences.

At the same time, preservice and new teachers need to see critiquing and adapting as authentic aspects of their job as teachers. In order to avoid encountering curriculum materials analysis as a destabilizing experience, these teachers also need help in seeing published materials as adaptable guides, despite being provided by cooperating teachers, mandated by school districts, and developed by curriculum writers. Additionally, preservice and new teachers need opportunities to develop their pedagogical design capacity for analyzing curriculum materials. By learning how to become effective curriculum decision makers, beginning teachers will be able to overcome the inevitable limitations of curriculum materials, take advantage of the learning opportunities within them, and continue to learn about analysis through their experience as teachers.

To scaffold the development of preservice teachers' analysis practices and beliefs, this study investigated how one class of preservice elementary teachers experienced the use of reform-based criteria in analyzing science curriculum materials. As preservice teachers learned about a criterion-based approach to analysis, this study examined what criteria they used in their analyses, how well they understood and applied the reform-based criteria, and where they needed additional support. Additionally, this study described preservice elementary teachers' beliefs about the authenticity of this teaching practice; their views about how, when, and why teachers analyze curriculum materials; and their comfort level with engaging in this design work. The findings from this study provide insights into theoretical frameworks on the teacher-curriculum materials relationship, suggesting new and important factors for consideration. It also informs the field's understanding of novice teachers' PCK for science teaching. Finally, this study also has important implications for the design of science teacher education and curriculum materials and for future research directions. In Chapter 3, I describe the research methods used in this study.

CHAPTER 3

RESEARCH METHODS

This chapter describes the study setting and methods for this study. I begin by describing the possible effects of my role as a researcher and course instructor on the study itself. I then provide a description of the research context and participants. I then discuss the role of design-based research in shaping the design and analysis of the study and detail four unique design aspects of this study. I conclude by describing the data collection methods and coding and analysis procedures.

Study Overview

In this study I described the ways in which one class of preservice elementary teachers analyzed curriculum materials as they planned science lessons during their elementary science methods course, and for a subset of preservice teachers, during their student teaching semester. To develop these descriptions, I collected and analyzed a variety of classroom assignments from the science methods course. The preservice teachers completed three lesson plan analysis assignments, which asked them to apply reform-based criteria in their analysis of pre-selected inquiry-oriented lesson plans. The preservice teachers also completed two reflective teaching assignments, which were similar in structure to the lesson plan analysis assignments except the preservice teachers selected their own criteria, obtained the lesson plans from their cooperating teachers, and taught the lessons in their field placements. The preservice teachers also completed pre/posttests, which asked them to analyze a pre-selected inquiry-oriented lesson plan but did not ask them to use criteria specifically. These data sources enabled me to describe the preservice elementary teachers' pedagogical design capacity for critiquing and adapting science lesson plans and how this capacity changed over the course of a semester as they learned about these design practices. In addition to the course assignments, I interviewed a subset of the preservice teachers, once at the beginning and end of the science methods class and once at the end of the student teaching semester. I used this data source to describe preservice teachers' beliefs about and perceptions of curriculum materials analysis as well as their reasons for these beliefs and perceptions.

The Role of the Researcher

During the fall of 2006, I served as a field instructor for the preservice elementary teachers who were enrolled in their third semester of the teacher preparation program. As a field instructor, I co-planned, observed, and provided feedback on the math and science lessons that the preservice teachers taught in their field placements. During my experiences with helping them design their science lessons, I became interested in the differences I saw between how the preservice teachers analyzed lesson plans as part of an in-class activity and how they actually analyzed lessons that they were responsible for teaching in their field placements. Additionally, as part of a research study, I investigated the affordances and constraints of using educative supports to help preservice teachers critique and adapt lesson plans. Both of these experiences piqued my interest in better understanding how preservice elementary teachers plan with curriculum materials and how the science methods course can support their learning about how to engage in this design work. These interests shaped my ideas for the design of this study.

During the dissertation study, I served as the instructor for one of the two sections of the science methods course in Fall 2007 and as the primary researcher for this study. Assuming both roles required that I defined each ahead of time. As an instructor, I planned and led class sessions, provided in-class support for critiquing and adapting curriculum materials, and assessed and provided feedback on all written work (including assignments that were part of the data collection). As a researcher, I obtained consent at the beginning of the semester from the preservice teachers in order to use a subset of their coursework in my research study. I also selected and obtained consent from a subset of the preservice teachers in order to interview them during the study. Conducting interviews with my own students allowed me to establish a sense of rapport that facilitated personal and honest conversations that might not otherwise have been possible if conducted by an unknown researcher (Fontana & Frey, 1994). On the other hand, serving as their course instructor might have limited their sense of trust and openness during the interviews and compelled them to say what they thought I wanted them to say. This was one potential limitation of my study. However, my data suggest that I could believe what my students said in the interviews. For example, three interviewees at the end of the science methods course and all seven interviewees at the end of the student teaching semester said they did not use a criterion-based approach when engaged in curricular analysis, even though this approach to analysis was emphasized in the science methods course.

Aside from obtaining consent at the beginning of the semester, I did not assume a researcher role during the course itself, and with the exception of the interviewees, I only interacted with the preservice teachers as their course instructor. Because data collection did not occur during the class sessions themselves, I was free to assume the role of the instructor without feeling like my role as a researcher would compromise my ability to serve as their teacher. As for the subset of preservice teachers who were interviewed, the interviews minimally impacted their relationship with me as their course instructor and their work during the course since I conducted the interviews at the very beginning of the semester during weeks 2 and 3 of the course and after the last class session of the semester. Additionally, in obtaining consent to interview, I explained to the preservice teachers that participating in the interviews provided them with an additional opportunity to reflect upon their science teaching and provided me with useful feedback to improve the course for future preservice teachers. These rationales for participating in the interviews helped the preservice teachers see the interviews as tasks that extended and deepened our relationship as instructor and student rather than as isolated events that were inconsistent with my goals for them as their instructor and their goals for themselves as students in the course.

Study Setting & Participants

Research Context: The Elementary Science Methods Course

This research study focused on one elementary science methods course at a large Midwestern university in the United States. This course took place during the third semester of an undergraduate teacher preparation program. This program consisted of four semesters of intensive professional study and was aligned with recommendations outlined by teacher education reform calls and standards documents (e.g., AAAS, 1993; NCTM, 1991; NCSS, 1994; NRC, 1996). Preservice teachers typically entered the program during their third year of college.

This program entailed strong academic preparation and intensive study and teaching in an elementary classroom. The preservice teachers took a variety of education courses during their first two semesters of the program, including a social studies methods course, which had a strong emphasis on curriculum materials development and adaptation. This course provided the preservice teachers with relevant curricular experiences before taking their science methods course. During the third semester, preservice teachers completed a mathematics methods course and a science methods course—the latter course being the focus of this study. In addition to relevant university coursework, preservice teachers also spent six hours each week of each semester in a K-6 classroom under the mentorship of an experienced classroom teacher. The fourth and final semester of the program entailed full-time student teaching.

The elementary science methods course itself met for three hours each week during the fall semester of their final year of college. The course was organized around three overarching conceptual themes (Davis & Smithey, in press). The first theme focused on helping the preservice teachers develop their understanding of inquiry-oriented science teaching, which was described in the course as engaging students in questioning and predicting, developing explanations based on evidence, and communicating and justifying explanations (NRC, 2000). The second theme of the course emphasized developing preservice teachers' understanding of the characteristics of students' ideas and strategies for identifying and working with students' ideas during instruction. The third theme focused on engaging preservice teachers in developing their pedagogical design capacity, specifically for critiquing and adapting curriculum materials in planning and teaching science. All three themes played an important role in this research study, with the third theme serving as the main focus in this investigation.

The science methods course involved a variety of activities and assignments to help the preservice teachers learn how to critique and adapt curriculum materials. At the beginning of the semester, the preservice teachers completed a pretest that allowed them to apply their own ideas in an analysis of a science lesson plan. The preservice teachers then used these ideas to generate an initial class list of criteria for analyzing science lesson plans. This activity enabled the preservice teachers to uncover and articulate their prior knowledge about analysis criteria. The class list of criteria also served as a starting point for future instruction as the preservice teachers learned about reform-based criteria during the methods course.

During the semester, six of the 13 class sessions focused on helping the preservice teachers learn about reform-based criteria, with approximately one class session devoted to each criterion. (See Chapter 2 for a description of these criteria.) Each class session began by connecting the criterion, if possible, to the list of analysis ideas generated at the beginning of the course. The preservice teachers then participated in a variety of in-class activities and discussions of course readings to develop their understanding of the criterion. At the end of each class, using exit slips, the preservice teachers recorded their ideas about indicators that they could use in analyzing science curriculum materials with regard to the criterion. These exit slips allowed the preservice teachers to use what they had learned from the class to articulate their own ideas about how they might apply the criterion in their analysis. These exit slips also allowed me to make explicit connections between the preservice teachers' own ideas and the indicators of each criterion that they used in their analysis of inquiry-oriented lesson plans during the course.

In addition to learning about reform-based criteria and applying them in their analysis of science lesson plans, the preservice teachers also participated in activities and assignments related to other learning goals for the other seven class sessions in the course. These activities engaged the preservice teachers in learning about the purposes for teaching science, science teaching resources, scientific modeling, the inquiry continuum, and strategies for managing an inquiry-oriented science classroom. Along with these activities, the preservice teachers completed a variety of assignments, including a pre/post-assessment and journal entry focused on scientific modeling, a pre/post-journal response focused on their ideas about effective science teaching, and a journal entry describing their science content conversation with a child. See Table 3.1 for a summary of the activities that the preservice teachers engaged in throughout the course.

Table 3.1
Description of Topics and In-Class Activities in the Science Methods Course

Week	Topic	In-Class Activities
1	Purposes for teaching science	- Discuss best/worst science experiences - Conduct inquiry-oriented science lab
2	Introduction to inquiry-oriented science teaching	- Examine written cases of different instructional models - Identify features of inquiry-oriented science teaching within previous lab and a video case
3*	Learning goals; Establishing purpose	- Analyze goals & investigation questions in lessons - Introduction to standards documents - Develop goals and questions from standards and activities
4*	Identifying students' initial ideas and predictions	- Watch video on students' ideas about science - Identify common characteristics of students' ideas - Critique different strategies for eliciting students' ideas - Identify strategies for eliciting students' predictions
5*	Providing experiences with phenomena; collecting and analyzing data	- Critique different experiences with phenomena for helping students learn about a particular concept - Design a benchmark lesson that provides students with multiple ways to experience a particular phenomenon - Work with data as part of a lab and explore different ways to support students in collecting and analyzing data
6*	Promoting student sense-making	- Examine students' ideas about different science topics elicited from their interviews with kids - Define the components of an evidence-based explanation - Develop explanations for lab conducted in previous week - Identify productive discussion moves within a video case - Co-plan their first reflective teaching assignment
7	Exploring resources	- Examining different resources for science teaching - Discuss controversial statements about inquiry teaching
8	Modeling	- Engage in the modeling practices within a science lab - Analyze a lesson plan for content and modeling practices
9*	Assessing student learning	- Identify different strategies for assessing student learning - Explore tradeoffs of different assessment strategies
10*	Making science accessible to all students	- Identify student resources/characteristics and consider them within the context of their own students - Explore ways within cases for building on these resources - Co-plan second reflective teaching assignment
11	Inquiry-oriented science teaching and the inquiry continuum	- Conduct a lab that varies along the inquiry continuum - Explore tradeoffs of student- vs. teacher-directed inquiry - Identify features of inquiry-based teaching and their place along the inquiry continuum within a video case
12	Managing a science class	- Discuss statements about curriculum materials analysis - Explore management considerations in written cases
13	Tying it together	- Compare pretest analysis with posttest analysis - Participate in practice job interviews

* Topics and activities pertaining to learning about the reform-based criteria.

Research Participants

The participants in this study included the preservice elementary teachers from one section of a science methods course who gave their consent to have me analyze their coursework for research purposes (24 of 28 students). I informed the preservice teachers that they could withdraw their consent for participation at any time during the study and that I would maintain confidentiality using pseudonyms for all participants. The preservice elementary teachers recruited for this study were representative of the population of elementary teachers in the United States. In other words, they were primarily white and female (NCES, 2007). Most were also traditional fourth-year college students in their final year of study. With regard to their teaching concentrations, only one preservice teacher had a science concentration. The other preservice teachers had teaching concentrations in other subject areas, including language arts (12/24), mathematics (6/24), and social studies (6/24). Most of the preservice teachers (20/24) hoped to obtain a teaching job when they completed the program.

A subset of the preservice teachers also participated in a series of interviews administered once at the beginning and end of the science methods course and once at the end of the student teaching semester. I selected seven participants based, in part, on their teaching concentrations in order to obtain a sample representing all of the different teaching concentrations within the class (see Table 3.2). I also selected participants based on their field placement locations in order to obtain a sample representing all of the different school districts within the class (see Table 3.3). Because each school district used a different science curricular program, this also allowed me to obtain a group of participants representing a variety of different types of curriculum materials. Interviewing seven preservice teachers rather than a smaller subset of participants allowed me to obtain a wide range of perspectives on curriculum materials analysis. Additionally, seven preservice teachers provided a reasonably-sized subset for recruiting preservice teachers to participate and for being able to collect the data within a reasonable time frame.

Table 3.2
Teaching Concentrations of Interviewees

Participant*	Main Teaching Concentration	Minor Teaching Concentration
Ashley	Social studies	Math
Chelsea	Language arts	Fine arts
Karen	Science	Math
Lisa	Social studies	Math
Leah	Math	Science
Shelley	Language arts	Math
Teresa	Math/social studies	n/a

* Pseudonyms are used for participants.

Table 3.3
Description of Field Placements of Interviewees

Participant	School District			Grade of Students Within Field Placement
	Name*	% of Minority Students[1]	% of Economically Disadvantages Students[2]	
Ashley	Weston	66.4	72.3	2
Chelsea	Candlewood	6.4	8.1	3
Karen	Appleton	30.9	19.0	5
Lisa	Candlewood	6.4	8.1	5
Leah	Young	69.7	57.9	5
Shelley	Appleton	30.9	19.0	4/5
Teresa	Clayton	23.1	10.6	4

* Pseudonyms are used for school districts.

With regard to their science subject matter preparation, results from a questionnaire administered at the beginning of the science methods course (described in detail in the "Data Sources" section below) showed that five of the seven participants

[1] These data are taken from the Council of Chief State School Officers' School Data Project for the 2008-2009 school year (CCSSO, 2008). The term minority is defined as individuals of Asian/Pacific Islander, Black, Hispanic, American Indian, or multi-racial descent.

[2] These data are taken from the Council of Chief State School Officers' School Data Project for the 2008-2009 school year (CCSSO, 2008). Economically disadvantaged is defined as students receiving free or reduced-price lunch under the National School Lunch Program as a result of low family income.

were under-prepared. These individuals had taken only basic science courses (i.e., biology, chemistry, physics) and had taken two or fewer of these courses at the college level. Unsurprisingly, these same five individuals reported having little confidence in their science knowledge. Only Karen and Leah, who had a major and minor teaching concentration in science, respectively (see Table 3.2 above), expressed confidence in their science subject matter knowledge and described adequate preparation for learning about science, having taken several classes in biology, chemistry, physics, and other science-related fields, with more than two of these courses taken at the college level. These results paralleled findings from the class as a whole in which roughly three-fourths of the preservice teachers expressed limited science preparation (18/24) and expressed little confidence in their science understandings (17/24).

Study Methods

Design-Based Research

This study involved a design-based research approach. Design-based research studies entail iterative cycles of activity and artifact design, implementation, analysis, and redesign with the purpose of developing instructional tools that promote student learning (Collins, 1992; Shavelson, Phillips, Towne, & Feuer, 2003). These cycles of research and design aim to investigate the impact of an intervention by describing the evolution of individuals' learning and the role of artifacts in supporting that learning while continually redesigning and improving the intervention (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003).

I adapted the assignments and tasks from previous designs of the course (Beyer & Davis, in press-a, in press-b; Davis, 2006; Davis & Smithey, in press). The initial course assignments and activities had the preservice teachers develop and refine their own ideas about analysis criteria (Davis, 2006). This approach promoted buy-in for using a criterion-based approach to analysis, but the preservice teachers' analysis ideas, though productive in some respects, were limited in others. Subsequent iterations of research and design moved toward a more instructor-driven set of criteria (Beyer & Davis, in press-a, in press-b). In these iterations, the preservice teachers defined and used criteria chosen by the course instructor, in addition to generating and using some of their own criteria. The ways in which this study built off these past designs is detailed in the section that follows.

Design-based research studies also aim to study patterns in learning within the authentic yet complex and messy setting of the classroom (Barab & Squire, 2004). Similarly, this study was situated in the naturalistic setting of a methods course for preservice elementary teachers, an uncommon yet fruitful context for this kind of research (Cobb et al., 2003). Conducting design-based research studies in this setting has the potential to improve instruction for preservice teachers (Bell, Hoadley, & Linn, 2004).

Finally, design-based research studies are theory driven. They are based on prior research and theory (Shavelson et al., 2003), and they also test and build upon theoretical frameworks that convey relevant findings about how people learn (Cobb et al., 2003; Edelson, 2002). The purpose of design studies is to "develop a class of theories about both the process of learning and the means that are designed to support that learning" (Cobb et al., 2003, p. 10). Therefore, design-based research studies aim not only to develop a useful product or an effective learning environment but also to advance theories about teaching and learning (Barab & Squire, 2004; Bell et al., 2004). I contribute to theoretical frameworks on curriculum materials use by identifying factors that impact how preservice teachers learn how to use science curriculum materials effectively in their planning.

Unique Design Aspects of the Study

Building upon past designs of the course, this study contained four unique design elements. First, this study explored the use of a set of well-specified, standards-based criteria in helping the preservice teachers develop a principled perspective on analysis. These criteria were based on a *modified* version of the AAAS Project 2061 analysis framework (Kesidou & Roseman, 2002; Stern & Roseman, 2004). As written, this framework includes several criteria organized into seven categories, and each criterion includes several indicators and a scoring rubric for judging how well the curriculum materials meet each criterion. The preservice teachers in this study used a simplified version of this framework. Their analyses focused on six of the seven categories from the framework as well as one additional category—attending to learning goals. They referred to these categories as ‘criteria.’ Additionally, they only used a small subset of the criteria from the original framework as well as some innovated ones as ‘indicators’ in their analysis. Each criterion included three indicators. I phrased the indicators for each criterion as questions to which the preservice teachers could think about and respond. The Project 2061 scoring rubrics were excluded from the study. Finally, when introducing the criteria, I made explicit the connections between the preservice teachers’ analysis ideas that emerged from the pretests and exit slips (described above) and the reform-based criteria and their respective indicators.

These modifications to the Project 2061 criteria were based on a variety of reasons. First, this study had the benefit of building upon the work of Schwarz and colleagues (2008) who also used a subset the Project 2061 criteria with their preservice elementary teachers, enabling me to try to mitigate some of the issues that arose in their study. In their study they introduced the criteria without making explicit connections to preservice teachers' prior knowledge and embedded the criteria within structured analysis forms for the preservice teachers to complete when analyzing lesson plans. As a result, they found that the preservice teachers did not view the criteria as useful, in part, because they viewed the forms as too detailed and time-consuming and because they perceived little overlap between the reform-based criteria and their own goals and criteria. This finding influenced how I adapted and presented the criteria from the Project 2061 analysis framework. A second reason for the modifications is that the Project 2061 criteria are intended for use in analyzing textbooks, not individual lesson plans, which was the focus in the course. Third, extensive training is required before individuals can effectively use this analysis framework—an opportunity not afforded by the time constraints of a one-semester course with other demands. Finally, focusing at a larger grain size was hypothesized to provide a more accessible entry point for learning about curriculum materials analysis, especially for individuals learning about a criterion-based approach to analysis for the first time.

In addition to examining the preservice teachers' use of a modified version of the Project 2061 framework, a second unique design feature included investigating the preservice teachers' application of one of the reform-based criterion using multiple lesson plans. Previous reports have found that having preservice teachers apply criteria only once within a scaffolded task resulted in mixed success in applying the criteria as intended (Schwarz et al., 2008) and limited long-term changes in their understanding of the criteria (Beyer & Davis, in press-a). Additionally, researchers have argued that supports need to be gradually faded as learners' understandings develop rather than abruptly removed before learners are ready to complete the task on their own (Collins, Brown & Newman, 1989; Pea, 2004). Therefore, this study had preservice teachers repeatedly apply one of the criteria across multiple lesson plan analysis tasks in order to examine how preservice teachers understand and apply the reform-based criteria when provided with multiple opportunities to practice applying them.

A third unique design feature of this study included the examination of preservice elementary teachers' analysis experiences within authentic activity. Previous studies have found that preservice teachers do not necessarily see the ideas that they have learned about from structured lesson plan analysis tasks as relevant to their own teaching practice (Nicol & Crespo, 2006; Schwarz et al., 2008). Additionally, preservice teachers have primarily been asked to analyze textbooks or lesson plans in a low-stakes setting, where they are not responsible for putting the lesson plans they analyze into practice (Beyer & Davis, in press-a, in press-b; Davis, 2006; Lloyd & Behm, 2005; Nicol & Crespo, 2006; Schwarz et al., 2008). Therefore, this study examined preservice teachers' engagement with more authentic analysis experiences. Specifically, the preservice teachers applied criteria in the analysis of two lesson plans that they were responsible for teaching to their students in their field placements. These analysis experiences shed light on the preservice teachers' capacity to apply what they had learned from class to their own practice and their views about the relevancy of this teaching task to their work as future teachers.

Finally, this study described preservice teachers' queries into their own cooperating teachers' planning practices in order to help them see curricular analysis, in general, and the reform-based criteria, specifically, as relevant to teaching practice. Previous studies have found that preservice teachers do not necessarily see critiquing and adapting as authentic teaching tasks (Bullough, 1992; Nicol & Crespo, 2006; Schwarz et al., 2008). Therefore, this study had preservice teachers make observations of and engage in conversations with their cooperating teachers in order to find out how they plan for science instruction. This experience shed light on the development of preservice teachers' ideas about the extent to which and the reasons why teachers critique and adapt lesson plans during planning.

Data Sources

Many of the course assignments served as data for this study. These assignments included the preservice teachers' pre/posttests, lesson plan analysis assignments, reflective teaching assignments, and curriculum materials use assignment. I also conducted interviews with a subset of the preservice teachers. Table 3.4 provides an overview of the data sources, the purpose of each data source, and the frequency and timing of its collection, and Table 3.5 summarizes the data collection schedule.

Table 3.4
Overview of Data Sources

Data Source	Frequency	Group Size	Purpose
Pre/Posttests	Two assessments administered at the beginning and end of the fall semester	Whole class	To describe the extent to which they use a criterion-based approach within an open-ended analysis task. To identify what criteria they use in their analyses and how well they apply the reform-based criteria. To identify changes over time with regard to their analysis approaches, criteria choices, and application of the reform-based criteria.
Lesson Plan Analysis Assignments	Three assignments distributed across the fall semester	Whole class	To describe how well they apply reform-based criteria as they analyze an inquiry-oriented science lesson plan chosen by their instructor.
Reflective Teaching Assignments	Two assignments assigned during the fall semester	Whole class	To describe how they critique and adapt lesson plans that they are responsible for enacting in their placements. To identify what criteria they use in their analyses and how well their revised lesson plans address the reform-based criteria.
Curriculum Materials Use Assignment	One assignment assigned near the beginning of the fall semester	Whole Class	To identify reasons for why they think curriculum materials analysis is or is not an authentic teaching practice.
Questionnaire	Once at beginning of fall semester	Whole Class	To describe their subject matter preparation and confidence in knowledge of science and science teaching.
Audio-taped Interviews	Three interviews conducted once at the beginning and end of the fall semester and once at the end of the student teaching semester	Subset of preservice teachers (n = 7)	To describe their perceptions of their analysis approaches and their ideas about analysis criteria and how they change over time. To identify their views on the usefulness and authenticity of curriculum materials analysis and describe how their views change over time. To describe their comfort level with analyzing curriculum materials and factors impacting it.

Table 3.5
Data Collection Schedule

Data Source	Fall Semester—Methods Course				Student Teaching
	September	October	November	December	…March
Pre/Posttests	P			P	
Lesson Plan Analysis Assignments		L1 L2	L3		
Reflective Teaching Assignments		R1		R2	
Curriculum Materials Use Assignment	C				
Questionnaire	Q				
Interviews	I1			I2	I3

Pre/Posttests. The preservice teachers individually completed a pretest and posttest as homework at the beginning and end of the science methods course, respectively. These assignments enabled the preservice teachers to uncover and articulate their own analysis ideas. The preservice teachers analyzed the same lesson plan for each assignment. Intended for fourth and fifth graders, the lesson plan used an inquiry-oriented approach to help students learn about the concepts of melting and insulation, engaging students in building a container to keep an ice cube from melting for as long as possible. Providing very few guidelines, the pre/posttests simply asked the preservice teachers to describe the strengths and weaknesses of the lesson plan and modify it to address the weaknesses that they identified (with the option of inserting the changes into the lesson plan itself). See Appendix A for this assignment.

I used this data source to describe how preservice elementary teachers critique and adapt lesson plans within an open-ended task, using an inquiry-oriented science lesson plan provided by their course instructor. Specifically, these assignments shed light on the extent to which the preservice teachers used a criterion-based approach to analysis and applied reform-based criteria and how their analysis approaches, criteria choices, and application of the reform-based criteria changed over the science methods course.

Lesson plan analysis assignments. The preservice teachers independently completed three lesson plan analysis assignments as homework during the science methods course. The preservice teachers analyzed a different inquiry-oriented science lesson plan for each assignment. The lesson plans represented a wide assortment of curriculum materials varying in content, grade level, and quality, providing preservice teachers with the opportunity to explore a range of resources. In the first assignment, the lesson plan focused on helping first and second graders learn about waterproofing as one of the properties of materials by having them test the ability of different materials to keep a cotton ball dry. The lesson plan for the second assignment involved the concept of seed dispersal, engaging second and third graders in investigating the seed dispersal methods of different types of seeds. In the third assignment, the lesson plan had fifth grade students learn about friction by testing how far a toy car can travel on a variety of different surfaces.

In each analysis, the preservice teachers practiced applying three criteria that they had learned about in class in their analysis of the lesson plan. Each lesson plan intentionally contained both strengths and weaknesses with regard to each criterion. For each criterion, the preservice teachers had to identify aspects of the lesson plan that met or did not meet each indicator, provide rationales or examples from the materials to justify their ideas, and describe adaptations they would make to improve the lesson plan. Each assignment specified which criteria they would use in their analysis (see Table 3.6). The preservice teachers applied each reform-based criterion only once across the assignments, with the exception of one criterion (i.e., ‘eliciting students’ initial ideas and predictions’), which they applied in all three assignments. I repeated one criterion across the lesson plan analysis assignments in order to see if repetition made a difference in preservice teachers’ understanding and application of the criteria. See Appendix B for the instructions given to the preservice teachers for this assignment.

Table 3.6
List of Reform-Based Criteria for Each Lesson Plan Analysis Assignment

Assignment	Reform-Based Criteria Targeted in Each Assignment
Lesson plan analysis assignment 1	Eliciting students’ initial ideas and predictions Establishing a sense of purpose Attending to learning goals
Lesson plan analysis assignment 2	Eliciting students’ initial ideas and predictions Providing experiences with phenomena Promoting student thinking
Lesson plan analysis assignment 3	Eliciting students’ initial ideas and predictions Assessing students’ ideas Making science accessible for all students

I used this data source to describe how well preservice teachers applied reform-based criteria in their analysis of pre-selected, inquiry-oriented science lesson plans. Specifically, these assignments shed light on how well the preservice teachers understood and applied each criterion, and with regard to the repeated criterion, how their understandings and applications of the criterion changed when provided with the opportunity to practice applying the same criterion across multiple lesson plans.

Reflective teaching assignments. The preservice teachers independently completed two reflective teaching assignments at the middle and end of the semester, providing them with the opportunity to teach two science lessons in their field placements. Each preservice teacher obtained their lesson plans from their cooperating teachers; these lesson plans were typically not inquiry-oriented. This assignment contained a lesson plan analysis task and a revised lesson plan (based on their analyses).

Like the lesson plan analysis assignments, the lesson plan analysis task within the reflective teaching assignment asked the preservice teachers to apply three criteria and their indicators by identifying aspects of the lesson plan that met or did not meet each indicator, justifying their ideas, and suggesting adaptations. However, unlike the lesson plan analysis assignment, this task allowed the preservice teachers to choose the criteria for their analysis. The revised lesson plan description in the reflective teaching assignment required preservice teachers to develop a complete lesson plan based on their analysis of their original lesson plan. The preservice teachers had three weeks to complete these parts of the assignment. See Appendix C for the instructions given to the preservice teachers. I used this data source to describe how the preservice elementary teachers critique and adapt lesson plans that they are responsible for enacting in their field placements. Specifically, these assignments shed light on their criteria choices as well as their capacity to address the reform-based criteria in their revised lesson plans.

Curriculum materials use assignment. The preservice teachers individually completed the curriculum materials use assignment as homework near the beginning of the semester. For this assignment, the preservice teachers obtained a lesson plan from their cooperating teacher, ideally for science, but if that was not possible, for any subject area. They then read through their cooperating teacher's lesson plan, observed its enactment, and reflected upon the lesson with their cooperating teacher. To facilitate this reflection, the preservice teachers received a list of questions to ask their cooperating teacher about how she or he planned for the lesson, specifically, and how she or he plans for instruction, more generally. The preservice teachers then completed a written response to specific questions asking them to describe what they have learned from this experience. See Appendix D for the instructions for this assignment. I used this data source to describe some of the reasons why preservice teachers think curriculum materials analysis is or is not an authentic teaching practice. For example, one of the reasons why preservice teachers may think curriculum materials analysis is or is not a part of teacher's daily work might be based on whether their cooperating teacher modifies lesson plans or not. This assignment also shed light on some of the preservice teachers' ideas about when, how, and why classroom teachers analyze lesson plans.

Questionnaire. During the first week of the science methods course, the preservice teachers individually completed a questionnaire as homework. The questionnaire asked them to specify their teaching concentration, list the number and type of science courses they had taken in high school and college, and rate their confidence level in teaching science and in their understanding of science. Appendix E includes a list of questions included in the questionnaire that were relevant to this study. I used this data source to describe the preservice teachers' confidence in their pedagogical content knowledge for science teaching and their science subject matter knowledge and the amount of science content preparation. These characteristics provided background information about the class as a whole and illuminated possible factors impacting preservice teachers' beliefs about and perceptions of curriculum materials analysis.

Interviews. I interviewed seven of the preservice teachers three times during the study, once at the beginning and end of the science methods course and once at the end of the student teaching semester. I used a semi-structured interview format (Patton, 1990), designing a set list of interview questions but modifying the order and wording of the questions as needed during the interview session. I also asked additional questions during the interviews if I needed to seek clarification or further probe the interviewee's thinking (Weiss, 1994). As part of the interview protocol, I reminded the preservice teachers that I was interested in their own perspectives and experiences and that they should feel welcome to respond openly and honestly to all questions, even if their perspectives were inconsistent with the goals of the science methods course. All three interviews were audio-recorded and transcribed. The first and second interviews were approximately sixty minutes, and the third interview was about forty-five minutes in length.

All three interviews focused on preservice teachers' views on what it means to be an effective elementary teacher and the role that curriculum materials should play in elementary science teaching. The interviews also elicited their observations of and beliefs about how classroom teachers use curriculum materials in planning for instruction. Additionally, the preservice teachers completed a card-sorting task where they sorted a list of criteria (including criteria learned in class and criteria related to their own ideas about how to analyze curriculum materials) into three categories: very important, somewhat important, and not important. The interviews also elicited the preservice teachers' ideas about how they see themselves teaching science and using science curriculum materials during their first year of teaching.

Additionally, in the first and second interviews only, I asked the preservice teachers to describe their analysis approaches and criteria choices with regard to the pre/posttests as well as their comfort level with analyzing curriculum materials and potential factors impacting it. In addition, during the second and third interviews only, I probed the preservice teachers' views on the authenticity of applying criteria in analyzing lesson plans. Finally, in the third interview, I asked the preservice teachers to describe their curricular planning experiences during their student teaching semester. See Appendix F for a list of questions used in the interview protocols and notes on the connection between each interview question and the research questions.

These three interviews served a variety of research purposes. First, the interviews enabled me to describe the preservice teachers' perceptions of their analysis approaches and criteria choices in the pre/posttests and during their student teaching semester in order to see if they adopted a criterion-based approach and used any of the reform-based criteria. Second, these interviews provided insight into the preservice teachers' views on the authenticity of curriculum materials analysis and a criterion-based approach to analysis and the importance of the reform-based criteria, in relation to their own ideas about analysis criteria. Third, these interviews uncovered the preservice teachers' comfort level with analyzing curriculum materials and the affordances and constraints impacting their level of comfort. Particular affordances and constraints probed during the interviews included the preservice teachers' perceived pedagogical design capacity for critiquing and adapting curriculum materials, perceived subject matter knowledge and confidence in their understandings of science, and their views about how other people (e.g., curriculum developers, cooperating teachers) shape the ways in which they use curriculum materials. Finally, conducting the interviews at three different points in time shed light on how the preservice teachers' beliefs and perceptions changed over time with regard to the three purposes described above.

Data Coding and Analysis

This section describes the data analysis approaches that I used to address the three main research questions: (1) *When introduced to reform-based criteria and asked to* *apply them in their analyses, what are preservice elementary teachers' understandings of the criteria and how do they apply them in their analyses of science lesson plans?*, (2) *When not explicitly asked to apply criteria in their analyses, how do preservice elementary teachers analyze science lesson plans and how do their analyses change over time?*, and (3) *What are preservice elementary teachers' beliefs about and perceptions of curriculum materials analysis? What reasons do they give for those beliefs and perceptions?* A series of analysis questions within each main research question guided the data analysis. These questions are outlined in Tables 3.7, 3.8, and 3.9, along with a list of data sources and hypothesized findings for each analysis question.

Table 3.7
Analysis Structure for Research Question 1

Analysis Questions	Hypotheses	Data Sources
1a. When asked to apply reform-based criteria in their critique and adaptation of inquiry-oriented science lesson plans chosen by the instructor, how well do the preservice teachers address the reform-based criteria in their analyses, and how do their analyses change when they repeatedly apply the same criterion across multiple lessons?	They will demonstrate basic understandings of and abilities with addressing the reform-based criteria when they apply the criteria for the first time. They will demonstrate more nuanced understandings and abilities when they practice using the same criterion in multiple contexts.	Lesson plan analysis assignments
1b. When asked to choose criteria and apply them in their critique and adaptation of their own lesson plans, what criteria do preservice teachers use, and how well do their analyses address the reform-based criteria?	They will choose the reform-based criteria more often than their own criteria. They will demonstrate basic understandings of and abilities with addressing the reform-based criteria in the analysis of their own lesson plans.	Reflective teaching assignments; Interviews

Table 3.8

Analysis Structure for Research Question 2

Analysis Questions	Hypotheses	Data Sources
When asked to analyze lesson plans (but not asked to apply criteria):		
2a. To what extent do preservice teachers use a criterion-based approach to analysis and how do their analysis approaches change over time?	They will initially analyze a lesson plan unsystematically but over time will develop a criterion-based approach and use this approach during their student teaching.	Pre/Posttests; Interviews
2b. How well do preservice teachers address the reform-based criteria in their analyses, and how do their analyses change over time?	They will fail to address most of the reform-based criteria in their initial analyses but will address most of the criteria by the end of the science methods course.	Pre/Posttests; Interviews
2c. What criteria (explicit or implicit) do preservice teachers use, and how do their criteria choices change over time?	They will initially choose criteria that represent less complex ideas about teaching but over time will use reform-based criteria and will continue to use the reform-based criteria during their student teaching.	Pre/Posttests; Interviews
2d. What are preservice teachers' views on the importance of their own criteria and the reform-based criteria, and how do their views change over time?	They will initially view their own criteria as more important but over time will view the reform-based criteria as more important and will continue to hold these views during their student teaching semester.	Interviews; Reflective teaching assignments

Table 3.9
Analysis Structure for Research Question 3

Analysis Questions	Hypotheses	Data Sources
3a. What are preservice teachers' beliefs about curriculum materials analysis, and what accounts for these beliefs?	Only a few will initially view curriculum materials analysis as authentic due to their limited experiences with using and observing others use curriculum materials in these ways. However, because of their experiences in the course, they will begin to view this teaching task as authentic and relevant aspects of teachers' work.	Interviews; Curriculum materials use assignment
3b. What are preservice teachers' comfort level with engaging in the practice of analyzing curriculum materials, and what accounts for these responses?	They will initially express little confidence in analyzing curriculum materials due to perceived constraints on their use of curriculum materials and gaps in their pedagogical design capacity. However, by the end of the semester, their perceptions will change, increasing their confidence in analyzing materials and their propensity to want to adapt curriculum materials	Interviews; Questionnaire

I describe the data coding and analysis procedures in the sections below. In addition to these procedures, I took a number of measures relevant to all data analyses to enhance the validity and reliability of this study. I had a second independent rater code a subset of the data (10%) and calculated inter-rater agreement (Krefting, 1991). Specifically, I calculated relative observed percent agreement and Cohen's kappa coefficient, which takes into consideration the agreement occurring by chance. Percent agreement between raters was 88%, and the value for kappa was 0.76, indicating substantial agreement. All disagreements were resolved through discussion. I also participated in discussions of my data analysis procedures and emerging findings with impartial colleagues at research meetings. This peer review process allowed me to obtain feedback on my coding schemes, emergent patterns, and interpretations, thereby bolstering the credibility of the assertions in this study (Johnson, 1997; Lincoln & Guba, 1985).

Criteria choices. I coded for the type of criteria that the preservice teachers used or mentioned (explicitly or implicitly) within the analysis tasks of the reflective teaching assignments, pre/posttests, and relevant segments of the interview transcripts (i.e., preservice teachers' reflections on how they completed the pre/posttests and planned with curriculum materials during the student teaching semester, their perspectives on the characteristics of effective elementary science teaching, and their ideas about how they anticipate planning for science lessons as future elementary science teachers). I derived the initial coding key using the reform-based criteria and iteratively revised it to account for the preservice teachers' own criteria that they used in the assignments (e.g., classroom management, cooperative learning). I identified the most common criteria among the preservice teachers' own criteria by determining which criteria were used by at least one-fourth of the preservice teachers in any one of the assignments. Once I identified and added these codes to the coding scheme, I then recoded all of the data using the finalized coding scheme described in Table 3.10.

Table 3.10

Coding Scheme for the Type of Criteria that the Preservice Teachers Used or Mentioned

Code	Example
Reform-Based Criteria	
Attend to learning goals	Considers if inquiry and content learning goals are addressed and aligned with standards and the lesson activities.
Sense of purpose	Considers if the purpose of the lesson is explicit, relevant, understandable, and/or interesting to students.
Elicit students' ideas	Considers if the lesson provides strategies for eliciting and interpreting students' prior knowledge and predictions.
Experience phenomena	Considers if the lesson provides experiences with phenomena and opportunities to collect and analyze data
Sense-making	Considers if the lesson provides strategies for guiding student interpretation & opportunities to develop explanations.
Assessment	Considers if the lesson assesses each student's understanding and skills and has them apply their ideas to new tasks
Accessible science	Considers if the lesson enables all students to experience success and see connections between their personal experiences and science.
Emergent Criteria	
Fun/engaging	Considers if the lesson engages students and makes science fun and interesting
Clarity & feasibility	Considers if the lesson provides clear, feasible information for the teacher in terms of completing activities
Hands-on	Considers if the lesson provides students with hands-on activities or experiments
Classroom management	Considers if the lesson provides the teacher with guidance on how to manage student behavior
Providing explanations	Considers if the lesson provides students with adequate explanations of phenomena and definitions of terms
Cooperative learning	Considers if the lesson enables students to support their learning through group work
Student directedness	Considers if the lesson enables the students to develop their own understandings or design their own investigations

After coding the preservice teachers' responses, I then quantified the data in order to foster more meaningful comparisons and allow patterns to be identified and further explored (Chi, 1997; Miles & Huberman, 1994). I calculated the mean number of reform-based criteria and the mean number of their own criteria that the individuals in the class used in each assignment.

Then, for the reflective teaching assignments only, I conducted two-tailed paired samples t-tests in order to compare the two types of criteria for each assignment. These comparisons provided insight into the extent to which the preservice teachers used the reform-based criteria, in comparison to their own criteria, when analyzing their own lesson plans.

Similarly, for the pre/posttests, I conducted two-tailed paired samples t-tests in order to compare their use of the reform-based criteria with their own criteria on the pretests and posttests and to describe any changes over time in their use of each type of criteria. To triangulate with findings from the pre/posttests, I also identified patterns in the types of criteria that the preservice teachers mentioned in each interview and compared them across time. These patterns provided insight into the interviewees' use of the reform-based criteria versus their own criteria and how their criteria choices changed from the beginning to the end of the science methods course and into their student teaching semester.

For the pre/posttests, I also calculated in each assignment the mean number of claims (i.e., strengths and weaknesses) dealing with the reform-based criteria and the mean number of claims dealing with their own criteria. I then conducted two-tailed paired samples t-tests in order to compare the amount of focus on the reform-based criteria versus their own criteria in the pretests and posttests and to describe any change over time in the amount of focus for each type of criteria.

For both the reflective teaching assignments and pre/posttests, I also calculated the mean number of preservice teachers who used *each reform-based criterion* for each assignment. I then conducted repeated measures one-way ANOVAs to determine if there was any statistical difference in the means across the reform-based criteria for each assignment and conducted follow-up comparisons with error rate corrections and alpha at .05. For these ANOVAs and all others in this study, I used the Greenhouse-Geisser conservative F-test as a correction to guard against violations of the sphericity assumption, and I used the Bonferroni inequality to control for Type I error rate during follow-up pairwise comparisons. This analysis shed light on potential differences in the number of preservice teachers choosing each reform-based criterion, in general, within each assignment, and whether they chose criterion 3 (i.e., the criterion repeated across the lesson plan analysis assignments) more often than the other criteria, specifically.

Views on the usefulness of criteria. I coded interview segments dealing with the preservice teachers' views on the usefulness of the reform-based criteria versus their own criteria. I coded these segments for preservice teachers' views on each criterion's level of importance (i.e., not or somewhat important, very or most important). I then calculated the mean number of reform-based criteria and the mean number of their own criteria that the preservice teachers selected for each level of importance. I then conducted two-tailed paired samples t-tests in order to determine if the interviewees' views on the importance of the reform-based criteria versus their own criteria differed significantly. I also conducted repeated measures one-way ANOVAs and follow-up comparisons to determine if their views on the level of importance of each type of criteria changed over time from the beginning to the end of the science methods course and into their student teaching semester. These patterns provided insights into changes over time in the preservice teachers' views on the usefulness of the reform-based criteria and their own criteria.

Analysis approaches. I wrote summaries of each pre/posttest in order to describe the structure and content of each preservice teacher's analysis. In developing the summaries, I created a bulleted list of the claims (i.e., the strengths and weaknesses that they identified) in the order described by each preservice teacher. I then coded each claim for connections to the analysis criteria, as described above in Table 3.10. I also noted whether each claim pertained to a specific part of the lesson plan, and if so, what part to which the claim referred. After I developed these summaries, I then looked for patterns in the list of claims and how these patterns changed over time. Specifically, I looked for patterns in the types of ideas that the preservice teachers focused on in their analysis and their connection (if any) to the layout of the lesson plan itself. These patterns shed light on whether the preservice teachers used a criterion-based approach to analysis, and if not, what other type of approach they might have used in their analysis.

In order to triangulate with findings from the pre/posttests, I also analyzed relevant segments of the interview transcripts, including the preservice teachers' ideas about how they anticipate planning with curriculum materials as future elementary science teachers and their reflections on how they completed the pre/posttests and planned with curriculum materials during the student teaching semester. I analyzed these segments for the different approaches that the preservice teachers said they used in their analyses and how they changed over time. These patterns not only shed light on the different kinds of approaches that the preservice teachers used when analyzing science lesson plans but also provided insight into the extent to which they used a criterion-based approach to analysis and how their approaches changed over the course of the science methods class and into their student teaching semester

Application of reform-based criteria. I analyzed the preservice teachers' lesson plan analysis assignments, revised lesson plan descriptions in the reflective teaching assignments, and pre/posttests to determine whether they addressed the indicators of each reform-based criterion. I created a list of codes based on the reform-based criteria and sub-codes based on the indicators. The preservice teachers received the criteria and their indicators as part of the lesson plan analysis assignments. Table 3.11 includes this list of codes and sub-codes used in the analysis.

Table 3.11

Coding Scheme for the Application of the Reform-Based Criteria

Code	Sub-Code	Example
Attending to learning goals	Address content and inquiry	Learning goals address both science content and inquiry.
	Connection to standards	Learning goals are grade-appropriate and aligned with standards documents.
	Alignment with lesson	Learning goals are aligned with the activities in the lesson plan.
Establishing a purpose	Explicit purpose	Lesson prompts teacher to make lesson purpose explicit to students
	Meaningful purpose	Purpose is likely to be meaningful to students and anchored in the lives of learners.
	Connected purpose	Lesson helps teacher connect the purpose to what students have been learning about thus far in class.
Eliciting students' initial ideas and predictions	Elicit ideas and predictions	Lesson enables teacher to elicit students' ideas about the new content and predictions about phenomena.
	Elicit explanations	Lesson asks students to give explanations for their ideas/predictions.
	Record and share ideas	Lesson provides opportunities for students' ideas to be recorded and shared with others in the class.
Providing experiences with phenomena	Multiple experiences	Lesson provides multiple experiences with phenomena—first- and second-hand experiences.
	Data collection	Lesson engages students in recording their data or observations.
	Data analysis	Lesson provides engages students in sharing their results and looking for patterns in the data.
Promoting students' sense-making	Evidence-based explanations	Lesson provides students with the opportunity to use evidence in support of a claim.
	Discussion questions	Lesson provides teachers with questions to help students interpret their experiences with phenomena.
	Revisiting of initial ideas	Lesson provides opportunities for students to revisit their initial ideas and predictions.
Assessing student learning	Assess content and inquiry	Lesson provides teachers with assessments that allow them to assess inquiry skills and science ideas.
	Assess each student	Lesson provides teachers with assessments that allow each student to demonstrate understanding and skills.
	Application of ideas	Lesson provides teachers with assessments that require students to apply their ideas to a new task/situation.
Making science accessible for all students	Attend to individuals	Lesson helps preservice teacher attend to the needs of individual students in his or her classroom.
	Make explicit connections	Lesson enables students to make connections between scientific ideas and their personal experiences.
	Make terms accessible	Lesson helps teachers make terminology accessible to all students.

For each indicator, I analyzed the preservice teachers' response to determine whether they understood the intent of the indicator. I determined whether they understood its intent by analyzing their response for the presence of an accurate or inaccurate claim about whether the lesson plan met the indicator or not and the presence of correct or incorrect examples to support their claim (for a similar approach, see Schwarz et al., 2008). Each response that demonstrated an understanding of the indicator received one point and each response that demonstrated a lack of understanding received no points. Next, for each preservice teacher, I added up the points and assigned an overall score for each criterion based on how many indicators the preservice teachers accurately addressed in their analysis (see Table 3.12 for scoring rubric). Since each criterion had three indicators, the maximum score for any criterion was three. For each assignment I then averaged the scores across the preservice teachers for each criterion. I then conducted a repeated measures one-way analysis of variance (ANOVA) to determine if there was any statistical difference in the mean scores across criteria for each assignment, followed by post hoc pairwise comparisons. These comparisons illuminated potential differences in the preservice teachers' understanding of the reform-based criteria, shedding light on whether they had difficulty addressing some criteria more than others.

Table 3.12
Scoring Rubric for Assessing Preservice Teachers' Understanding of Reform-Based Criteria

Score	Description
3	Demonstrates strong understanding and use of criterion. (All 3 indicators met.)
2	Demonstrates adequate understanding and use of criterion. (Only 2 indicators met.)
1	Demonstrates weak or partial understanding and use of criterion. (Only 1 indicator met.)
0	Does not demonstrate understanding and use of criterion. (No indicators met.)

I conducted other statistical tests in order to describe changes in the mean scores over time. With regard to the lesson plan analysis assignments, I performed a repeated measures one-way ANOVA to determine if there was any statistical difference in the mean scores across assignments for criterion 3, which was the only criterion repeated across the assignments. I then conducted follow-up pairwise comparisons, corrected using Bonferroni adjustments. Examining changes in scores across the semester shed light on how well the preservice teachers analyzed the lesson plan with regard to this criterion and how their understanding and application of it changed across the semester as they practiced applying it using different lesson plans.

Additionally, with regard to the pre/posttests, I conducted one-tailed paired samples t-tests to determine if there was any statistical difference across time in the mean scores for each criterion. I conducted one-tailed, rather than two-tailed, t-tests because the pretest scores were extremely low to begin with and I hypothesized that the posttest scores would be higher after the preservice teachers had the opportunity to learn about the reform-based criteria. These comparisons provided insight into whether the preservice teachers improved in their understanding and application of the reform-based criteria after experiencing the methods course.

Finally, for the lesson plan analysis assignments and reflective teaching assignments, I calculated the frequency and percentage of preservice teachers who demonstrated an understanding of *each indicator* in order to discern with which components of each criterion the preservice teachers tended to struggle. I then coded their analyses for evidence of alternative understandings of the analysis criteria. I developed these codes from their analyses and identified patterns in these codes across the preservice teachers. This analysis shed light on the common alternative understandings they demonstrated about each criterion within each assignment.

Beliefs about curriculum materials analysis. I analyzed relevant segments of the interview transcripts for preservice teachers' beliefs about curriculum materials analysis. I analyzed segments dealing with their views on how effective elementary teachers use curriculum materials, how they think they will plan with curriculum materials as future elementary science teachers, how their cooperating teachers have used curriculum materials, and how they think classroom teachers actually use curriculum materials in their daily work. Within these segments, I used open coding strategies in my data analysis in order to develop an understanding of the preservice teachers' own beliefs and how they changed over time (Strauss & Corbin, 1998). Specifically, I iteratively read the interview transcripts and added comments to sentences or paragraphs related to my analysis questions dealing with preservice teachers' beliefs about curriculum materials analysis and factors accounting for their beliefs. I then identified codes and sub-codes from these descriptive comments (see Table 3.13). Next I ascertained themes for each code by identifying common sub-codes or groups of sub-codes among the preservice teachers. For example, one theme was that at the beginning of the course, the preservice teachers tended to view curriculum materials analysis as a task that occurs only during and after instruction, not before instruction. I then examined how these themes changed across time from the beginning to the end of the science methods course and into the student teaching semester. These themes shed light on the preservice teachers' evolving beliefs about the authenticity of curriculum materials analysis and about when, how, and why teacher analyze lesson plans.

Table 3.13
Codes and Sub-Codes for Beliefs about Curriculum Materials Analysis and Factors Impacting Beliefs

Analysis Question	Codes	Sub-Codes
What are preservice teachers' beliefs about curriculum materials analysis?	Authenticity of curriculum materials analysis	Authentic part of teaching practice Inauthentic part of teaching practice
	Why teacher analyze curriculum materials	For specific students (needs, abilities, interests, behavior, backgrounds) For their own teaching style For local standards For specific context (time constraints, resource constraints) For consistency with reform-based teaching
	When teachers analyze curriculum materials	Before instruction During instruction After instruction
	How teachers analyze curriculum materials	Large-scale changes Small-scale changes
What accounts for preservice teachers' beliefs?	Factors impacting preservice teachers' beliefs	Science methods course Cooperating teacher's analysis practices consistent with the course Cooperating teacher's analysis practices inconsistent with the course

I also analyzed the curriculum materials use assignment in order to triangulate with findings from the interview data. I analyzed the preservice teachers' descriptions for how their cooperating teacher used curriculum materials in planning for science instruction and the reasons they gave for why their cooperating teacher engaged in this teaching task. I used the same coding and analysis strategies described above. This analysis shed light on preservice teachers' views on curriculum materials analysis and some of the factors impacting their beliefs.

Comfort level with analyzing curriculum materials. I analyzed relevant segments of the interview transcripts for preservice teachers' comfort level with critiquing and adapting curriculum materials. I analyzed specific segments dealing with the preservice teachers' descriptions of their comfort level with analyzing science lesson plans and their perceptions of the affordances and constraints impacting their comfort level. I analyzed these segments for preservice teachers' comfort level with engaging in curriculum materials analysis and for the ways in which their perceptions of their pedagogical design capacity and the knowledge and authority of their cooperating teachers, curriculum developers, and future colleagues impacted their comfort level. I then identified patterns among the interviewees at the beginning and end of the science methods course. These patterns provided insight into the preservice teachers' perceptions of their ability to analyze science curriculum materials, their beliefs about the factors impacting their use of curriculum materials in planning science lessons, and how these perceptions and beliefs changed over time.

I also analyzed the preservice teachers' questionnaires in order to triangulate with the interview transcripts. I coded the data based on preservice teachers' confidence in teaching science, confidence in their science subject matter knowledge, and amount of science preparation. I developed these codes from the questions in the questionnaire. Table 3.14 summaries the codes and sub-codes used in the analysis. I then calculated the frequency and percentage of preservice teachers demonstrating each sub-code in order to identify patterns in the data. This analysis provided insight into the preservice teachers' science background preparation and their level of confidence in understanding and teaching science at the beginning of the science methods course. I used this information to triangulate with the patterns that emerged from the interview transcripts dealing with the preservice teachers' beliefs about the factors impacting their comfort level with analyzing science lesson plans.

Table 3.14
Scoring Rubric for Assessing Preservice Teachers' Personal Characteristics

Code	Sub-Code
Confidence in teaching science	Very or somewhat nervous about teaching science Pretty or very confident about teaching science
Confidence in science knowledge	Not confident in science knowledge. Confident in science knowledge.
Amount of science courses taken	Took mainly only basic science courses (i.e., biology, chemistry, physics), and took two or fewer of these courses at college Took several classes in biology, chemistry, and physics and other science classes & took more than two of these courses at college.

In the first results chapter (Chapter 4), I describe how the preservice teachers applied the reform-based criteria in their course assignments that were intended to help them learn how to apply criteria in their analyses—the lesson plan analysis assignments and the reflective teaching assignments. In the second results chapter (Chapter 5), I describe changes in preservice teachers' analysis approaches, criteria choices, application of the reform-based criteria, and views on the usefulness of criteria at the end of the science methods course after learning about a criterion-based approach to analysis and at the end of their student teaching semester. I draw upon their pre/posttests and interview transcripts to describe these changes across time. In the final results chapter (Chapter 6), I use the interview transcripts, curriculum materials use assignment, and questionnaire to describe preservice teachers' beliefs about curriculum materials analysis and their comfort level with engaging in this design task.

Conclusions

This chapter described the research context and participants and the methodological approaches used in this study to address my three main research questions. This study used a design-based approach to research to investigate the impact of using reform-based criteria as an intervention in scaffolding the development of an analytical stance toward curriculum materials. Design-based research enabled me to describe the evolution of preservice teachers' pedagogical design capacity for analyzing curriculum materials and the role of reform-based criteria in supporting this development. I drew upon course assignments, pre/posttests, and interview transcripts collected during the methods course and student teaching semester. In analyzing the data, I developed and iteratively revised coding schemes to account for emergent codes. After coding the data, I quantified, as appropriate, some of the codes in order to foster more meaningful comparisons of the data and conducted statistical tests. I then identified emergent themes in the coded and quantified data in order to describe the preservice teachers' criteria choices, applications of the reform-based criteria, beliefs about the authenticity of curriculum materials analysis, and comfort level with analyzing science lesson plans and how these changed over time. The next three chapters present the results of my analyses, as organized around my research questions.

CHAPTER 4

PRESERVICE TEACHERS' UNDERSTANDING AND APPLICATION OF REFORM-BASED CRITERIA

The results presented in this chapter inform the first of my three research questions, which asks: *When introduced to reform-based criteria and asked to apply them in their analyses, what are preservice elementary teachers' understandings of the criteria and how do they apply them in their analyses of science lesson plans?* This chapter describes how well the preservice teachers applied seven reform-based criteria in the lesson plan analysis assignments, after learning about the criteria in class. In these assignments, the preservice teachers analyzed inquiry-oriented lesson plans provided by me as their course instructor. The chapter also describes how well the preservice teachers applied the reform-based criteria in the reflective teaching assignments, after having the opportunity to practice applying the criteria in the lesson plan analysis assignments. In the reflective teaching assignments, the preservice teachers analyzed their own lesson plans that they were responsible for teaching in their field placements. In addition to describing areas of strength in the preservice teachers' understanding of the reform-based criteria, the chapter also sheds light on some of the common alternative understandings.

Overview of Results for Lesson Plan Analysis Assignments

The first section of this chapter addresses the following analysis questions: *When asked to apply reform-based criteria in their critique and adaptation of inquiry-oriented science lesson plans chosen by the instructor, how well do the preservice teachers* *address the reform-based criteria in their analyses, and how do their analyses change when they repeatedly apply the same criterion across multiple lessons?* To answer this question, I analyzed the preservice teachers' lesson plan analysis assignments in terms of their application of the reform-based criteria.

Results show that the preservice teachers demonstrated basic understanding and application of five of the seven reform-based criteria—'attending to learning goals,' 'establishing a sense of purpose,' 'eliciting students' initial ideas and predictions,' 'providing experiences with phenomena,' and 'promoting sense-making.' They demonstrated weak or partial understanding and application of the other two criteria—'assessing student learning' and 'making science accessible to all students.' Their lesson plan analyses illuminated alternative understandings of each criterion's indicators with which the preservice teachers tended to struggle. Additionally, the preservice teachers repeatedly applied one criterion—'eliciting students' initial ideas and predictions'—across the three lesson plan analysis assignments. Analyzing multiple lesson plans highlighting different strengths and weaknesses with regard to this criterion shed light on some of the preservice teachers' alternative understandings that would not have been illuminated if they had only analyzed one lesson plan. Thus, applying the same criterion to different lesson plans ultimately allowed the preservice teachers to improve their understanding of this criterion.

Lesson Plan Analysis Assignments: Understanding and Application of the Reform-Based Criteria

During the science methods course, the preservice teachers had the opportunity to learn about seven criteria that they could use to critique and adapt science lesson plans when designing instruction for students. Six of the seven criteria overlapped with the

AAAS Project 2061 instructional analysis criteria, which were developed by hundreds of teachers, researchers, teacher educators, and curriculum developers and grounded in current research on student learning (Kesidou & Roseman, 2002; Stern & Roseman, 2004). These criteria thus represent key ideas related to effective science teaching that are essential for promoting student learning. The six criteria included ‘establishing a sense of purpose’, ‘eliciting students’ initial ideas and predictions’, ‘providing experiences with phenomena’, ‘promoting students’ sense-making’, ‘assessing student learning’, and ‘making science accessible for all students’. The preservice teachers also had the opportunity to learn about one additional criterion: ‘attending to learning goals’.

After learning about each reform-based criterion, the preservice teachers demonstrated their understanding of the criteria by applying them in their analysis of lesson plans selected by their course instructor. A repeated measures analysis revealed that the lesson plan analysis scores differed significantly among the seven reform-based criteria, $F(4.28, 98.54) = 8.61$, $p = .000$, with a moderate effect size (partial eta-squared = .27). With error rate corrections, follow-up comparisons revealed that the scores for criteria 6 and 7 differed significantly from the rest of the criteria. Specifically, the preservice teachers demonstrated adequate understanding and application of five of the seven reform-based criteria but weak or partial understanding and application of two criteria: ‘assessing student learning’ and ‘making science accessible to all students’ (see Table 4.1).

Table 4.1

Mean Scores for Each Reform-Based Criterion in Lesson Plan Analysis Assignments

Criterion	Mean Score [a]	SD	Depth of Understanding [b]
1-Learning goals	1.67	0.92	Adequate
2-Purpose	1.96	0.86	Adequate
3-Eliciting ideas	1.92	0.83	Adequate
4-Experiencing phenomena	2.46	0.66	Adequate
5-Sense-making	2.04	0.91	Adequate
6-Assessment	1.25	0.79	Weak or partial
7-Accessible Science	1.21	0.83	Weak or partial

[a] Score represents the number of indicators addressed by each preservice teacher for each criterion; maximum score = 3.0. [b] 0.00 - 0.49 = No understanding; 0.50 - 1.49 = Weak or partial understanding; 1.50 – 2.49 = Adequate understanding; 2.50 – 3.00 = Strong understanding

Within each criterion, the preservice teachers varied in their understanding and application of the individual indicators. Most of the preservice teachers accurately addressed about half of the indicators. However, the preservice teachers tended to struggle in their applications of the other indicators, especially with regard to indicators 1b, 6b, 7a, 7c. Table 4.2 lists the frequency and percentage of preservice teachers who accurately addressed each indicator within the lesson plan analysis assignments.

Table 4.2
Number of Preservice Teachers Addressing Indicators within Lesson Plan Analysis Assignments

Criterion/Indicator	Individuals Who Addressed Indicator		
	Frequency[a]	Percentage	Category[b]
1—Attending to learning goals			
1a—Including content and inquiry goals	10	42%	Some
1b—Connecting learning goals to standards	8	33%	Few
1c—Aligning lesson to learning goals	22	92%	Most
2—Establishing a sense of purpose			
2a—Making the purpose explicit to students	22	92%	Most
2b—Making the purpose meaningful	14	58%	Some
2c—Connecting purpose to previous lessons	11	46%	Some
3—Eliciting students' initial ideas/predictions [c]			
3a—Eliciting ideas/predictions at start of lesson	16	67%	Most
3b—Eliciting explanations for ideas/predictions	16	67%	Most
3c—Having students record/share ideas	16	67%	Most
4—Providing experiences with phenomena			
4a—Providing multiple experiences	15	63%	Some
4b—Having students record data	24	100%	Most
4c—Having students share/interpret their data	20	83%	Most
5—Promoting sense-making			
5a—Having students develop explanations	16	67%	Most
5b—Asking guiding questions to discussion	12	50%	Some
5c—Asking students to revisit their initial ideas	22	92%	Most
6—Assessing student learning			
6a—Assessing understanding and inquiry abilities	9	38%	Some
6b—Assessing each student's ideas and abilities	3	13%	Few
6c—Asking students to apply ideas to new tasks	18	75%	Most
7—Making science accessible for all students			
7a—Attending to the individuals' needs	4	17%	Few
7b—Connecting to personal experiences	19	79%	Most
7c—Making scientific terms accessible to all	6	25%	Few

[a] Out of n = 24 preservice teachers
[b] Most = Two-thirds or more of the preservice teachers address indicator; Some = Greater than one-third but less than two-thirds of the preservice teachers address indicator; Few = One-third or fewer preservice teachers address indicator.
[c] Frequencies and percentages only reflect the preservice teachers' initial application of this criterion.

Examples illustrating an understanding of the indicators are described below as well as descriptions and examples of the common alternative understandings for the indicators that the majority of the preservice teachers did not understand.

Criterion 1—Attending to Learning Goals

1a—Including inquiry and content learning goals. Nearly half of the preservice teachers (10/24) understood what it meant to analyze learning goals to see if they addressed both science content and inquiry. In the first lesson plan analysis assignment, the lesson plan focused on helping first and second graders learn about waterproofing as one of the properties of materials by having them test the ability of different materials to keep a cotton ball dry. The lesson plan contained two learning goals focused solely on content: Students will identify waterproofing as one of the properties of materials, and students will distinguish between objects that are waterproof and those that are not. These preservice teachers recognized that the lesson plan did not include inquiry learning goals, leading them to incorporate them in the lesson. Amelia illustrates this analysis in the following excerpt:

> The learning goals listed in the lesson plan address science content. The first goal asks students to identify one useful property of materials, a learning goal that spans science topics and grade levels. The second goal asks students to classify objects according to a certain property, another learning goal that spans the entire science curriculum. However, the learning goals do not address inquiry. Neither learning goal addresses the inquiry process students will use in class. As the lesson stands now, an appropriate inquiry learning goal would be that 'Students will construct charts of and summarize their findings for the purpose of communicating with others' (aligned with MCFSC standard I.1.e6). Similarly, another learning goal would be that 'Students communicate their findings with others using data charts and graphs.' (Amelia, Lesson plan analysis assignment 1)

Even though several preservice teachers understood how to identify content and inquiry learning goals, one common alternative understanding predominated among the preservice teachers. Several individuals decided to examine whether the lesson plan itself was inquiry-oriented to determine if the learning goals addressed inquiry. Thus, in their analysis, they concluded that one or both of the stated learning goals addressed inquiry just because the lesson plan happened to be inquiry-oriented, even though the stated learning goals themselves did not include a focus on inquiry. The following example shows how Susan looked at the lesson plan itself to determine if the learning goals addressed inquiry. She writes:

> Yes, learning goal 1 addresses science content. Students explore properties of objects throughtout the lesson. Learning goal 2 addresses inquiry. Students will be able to make conclusions about whether or not certain objects are waterproof. They achieve this learning goal through the actual classroom activity involving the different materials, water and a cotton ball. Also, throughout the activity students are working as scientists. They work collaboratively in groups as scientists often do and record their data in an organized way. (Susan, Lesson plan analysis assignment 1)

This alternative understanding reflects that several preservice teachers did not understand the difference between having explicitly stated learning goals that address inquiry and having a lesson plan that includes inquiry practices. Interpreting the indicator in this way may result in missed opportunities for helping students develop their inquiry understandings and abilities.

1b—Connecting learning goals to standards. A third of the preservice teachers (8/24) understood what it meant for the learning goals to be grade appropriate and aligned with standards documents. In their analysis, these preservice teachers used the science standard documents for the respective grade level to determine if the learning goals were in fact grade appropriate and aligned with the standards, and they found that they were. Ashley demonstrates this correct application of the indicator, writing:

> The goals of the lesson address the science content standards that students of this grade should learn. According to the National Science Education Standards: Standard B, K-4 students should develop an understanding of the properties of objects and materials and the learning goals of this lesson indicate that students will be learning about a particular property of materials. This property is that of being waterproof…The learning goals are grade appropriate because as I stated earlier the content that they are learning aligns with the National science

> education standards for K-4 students. (Ashley, Lesson plan analysis assignment 1)

Even though some preservice teachers correctly applied this indicator, most of the preservice teachers had one of two alternative understandings. With regard to grade appropriateness, some preservice teachers did not use the standards to determine if the learning goals were appropriate for first and second graders—the grades targeted by the lesson plan that they had received. Instead, they determined if the learning goals were grade appropriate by using only their teacher sense. For example, Jessica decided for herself if she thought the learning goals were appropriate for early elementary students, writing, "I do believe the learning goals are grade-level appropriate because the inquiry is something that is manageable for second graders, while still providing them with the experience of developing an understanding of waterproof materials" (Lesson plan analysis assignment 1). Jackie also used her own intuition to determine if the learning goals were grade-appropriate but arrived at a very different conclusion. She wrote:

> [I]t seems that these learning goals might be a bit simplistic for students of this age and wouldn't really challenge them to engage in inquiry and discovery. Many young students already know that waterproofing is a characteristic of some objects, and probably already have some understanding of which objects possess this trait. I think it might be more beneficial to have learning goals that required them to dig deeper into the concept of waterproofing and to understand how it works and why certain object have the property. (Jackie, Lesson plan analysis assignment 1)

By not relying on the standards to inform their ideas about grade-appropriateness, these preservice teachers made different judgments about whether the learning goals were appropriate for first and second graders. Relying on one's own intuition solely for making decisions about what learning goals are appropriate or not appropriate for particular students may result in teachers underestimating what students are capable of learning or engaging students in science content about which they are not prepared to learn.

With regard to the standards, some preservice teachers had an alternative understanding about how to determine whether learning goals are aligned with standards documents. They thought they could just assume that the lesson plan would automatically be aligned with some set of standards and that it was not necessary for them to check if this was the case. Chelsea exemplifies this approach, writing:

> As for the science content learning goal, I also feel that it is well-aligned, since it fits well within the context of the unit as a whole (properties of matter), and I am assuming that the entire unit must be meeting some sort of state and/or local standards or benchmarks. (Chelsea, Lesson plan analysis assignment 1)

This typical example shows that some preservice teachers mistakenly thought the lesson plans that they would be given would necessarily be aligned with their state's or district's standards. Making this assumption may result in missed opportunities for students to learn about particular science content and inquiry practices.

1c—Aligning lesson activities to learning goals. Nearly every preservice teacher (22/24) understood what it meant for the learning goals to be aligned with the activities in the lesson plan. In their analysis, most of the preservice teachers stated that the learning goals in the lesson plan were aligned with the activities and provided evidence from the lesson plan to support their claim. The following example illustrates this systematic check for alignment between learning goals and the lesson activities:

> The learning goals are aligned with the activities because students are looking at several different materials to see if they possess the property of being waterproof. Also, they are making a chart in groups and as a class that distinguishes the waterproof materials from the not-waterproof materials. (Jackie, Lesson plan analysis assignment 1)

Jackie, like most of her peers, understood how to examine a lesson plan and its assessment for alignment with its stated learning goals.

Criterion 2—Establishing a Sense of Purpose

2a—Making the purpose explicit to students. Most of the preservice teachers (22/24) understood how to analyze a lesson plan with regard to making the lesson purpose explicit to students. In their analysis, the preservice teachers recognized that the purpose of the lesson was to help kids learn about another property of materials (waterproofing) and that the lesson helped the teacher make this purpose explicit to students. They pointed to different (but consistent) kinds of evidence to support this claim. For example, Jessica wrote:

> I believe the lesson does help teachers make explicit the purpose of the activity. Just the opening question introduces the idea of something being waterproof as the students think about how they can keep a cotton ball dry. Also, brainstorming ideas of how to keep something dry is a way to explicitly get students thinking about the concept of waterproofing. (Jessica, Lesson plan analysis assignment 1)

The preservice teachers experienced little difficulty in determining whether the lesson purpose was made explicit to students or not.

2b—Making the purpose meaningful to students. Over half of the class (14/24) understood how to help students see the lesson purpose as meaningful and anchored in their lives. The stated lesson purpose—to keep a cotton ball dry in the rain—was not likely to be meaningful and relevant to students' everyday lives. In their analysis, these preservice teachers addressed this weakness by adding a more meaningful and contextualized investigation question to the beginning of the lesson, for example, as Karen wrote:

> I think that [the purpose] could be more meaningful to students if students were first given the prompt: How can I stay dry when it is raining out? Or What is the best way to stay dry when it is raining out? That way this lesson may be more explicit to students when they understand that seeing what keeps the cotton ball dry could also help them see how they can stay dry in a rainstorm. (Karen, Lesson plan analysis assignment 1)

Even though some preservice teachers understood what it meant to provide students with a lesson purpose that is anchored in their everyday lives, other preservice teachers had an alternative understanding of this indicator. These individuals thought it was sufficient to analyze the lesson purpose to see if it was meaningful to the lives of learners without actually analyzing the lesson plan itself to see if helped students see the purpose as meaningful. Jackie illustrates this alternative understanding in her discussion of the lesson purpose on waterproofing, writing:

> The purpose of this lesson is quite relevant to students and is something that they will encounter in their lives. Many probably already have a lot of experiences with waterproof and non-waterproof material, although they may not have thought of it in that way at the time. Wearing raincoats or using umbrellas to keep themselves dry, or forgetting their raincoats and getting wet in their cotton t-shirt are experiences that almost all children can relate to. They have also probably encountered situations with food or drink in certain containers, which relates to waterproofing as well…All of this information is relevant to the student's lives. (Jackie, Lesson plan analysis assignment 1)

Preservice teachers like Jackie thought that just because the lesson purpose was meaningful and anchored in the lives of learners that students would automatically see it as such. Interpreting the indicator in this way may result in missed opportunities for them as teachers to help their students see how lessons relate to their everyday lives.

2c—Connecting the purpose to previous lessons. Half of the class (12/24) understood what it meant to analyze a lesson plan with regard to how well it helped students see the lesson as connected to previous lessons. In their analysis, they recognized that the lesson plan did connect with what students had been learning about in class but did not help students see these connections. To address this weakness, most of the preservice teachers suggested adding either a review session or teacher explanation to the beginning of the lesson to make these connections more explicit, as Melanie illustrates here:

> [B]efore this lesson began to unfold, I think it would have been very useful for the teacher to do a quick review or summary of what they have been learning as far as the different properties of matter, have them name the properties they've learned thus far, and then ask if they think they know of another property. (Melanie, Lesson plan analysis assignment 1)

The other half of the class had an alternative understanding of this indicator. They analyzed the lesson plan in terms of how well it connected with what students had been learning about in class, not in terms of how well it helped students recognize these connections. Morgan demonstrated this understanding, stating that the lesson did help the teacher connect the purpose of the activity to what students have been learning about thus far in class. She wrote, “The purpose of the activity in this lesson is connected with the learning so far. They have been looking at observable characteristics of materials and waterproofing is another observable characteristic” (Lesson plan analysis assignment 1). These preservice teachers assumed that just because a lesson was connected with previous lessons that these connections would be obvious to students. Possessing this alternative understanding may result in missed opportunities for the preservice teachers to help their students see the connections between lessons.

Criterion 3—Eliciting Students’ Initial Ideas and Predictions

The following examples below illustrate the preservice teachers’ understandings of ‘eliciting students’ initial ideas and predictions’ in their initial application of this criterion. Results from their additional applications of this criterion are presented in a separate section following the presentation of results for all seven criteria.

3a—Eliciting ideas and predictions at start of lesson. On the first lesson plan analysis assignment, two-thirds of the class (16/24) understood how to examine a lesson plan for how well it helped teachers elicit students' ideas about the new content and their predictions about the phenomena. In their analysis, these preservice teachers attended to both students' ideas and predictions in their response and recognized that the lesson did, in fact, elicit both. Lisa demonstrates this understanding, writing:

> Students are given the opportunity to reflect on their ideas before the lesson begins when they are asked to draw a picture of how one could protect a cotton ball in the rain. In addition, they are given a space in which to record their predictions regarding whether each material being tested in the investigation will be waterproof or not. (Lisa, Lesson plan analysis assignment 1)

Therefore, the majority of the preservice teachers had an accurate understanding of this indicator.

3b—Eliciting explanations for students' ideas/predictions. Two-thirds of the preservice teachers (16/24) understood how to analyze the lesson plan to have students give explanations for their initial ideas and predictions. In their analysis, they recognized that the lesson did not provide opportunities for students to give explanations and thus added prompts for explanations to the student worksheets and whole class discussion. Amelia illustrates these modifications, writing:

> [S]tudents are not asked to explain their ideas and predictions. They are simply asked to draw a picture in their journals and mark boxes on their charts. Students should be asked why they would use that item or material to keep a cotton ball dry in the rain and why they think the cotton ball in their investigation will or will not get wet. Students can explain in writing or by communicating verbally with their classmates and teacher. In my proposed journal questions, students must explain why they believe what they believe. I would also have students verbalize the reasoning behind their predictions to their group members and other classmates. (Amelia, Lesson plan analysis assignment 1)

This typical example characterizes how most of the preservice teachers understood how to identify whether students provided explanations for their ideas and predictions and made appropriate modifications, thereby providing opportunities to probe beneath students' responses.

3c—Having students record and share their ideas/predictions. Two-thirds of the preservice teachers (16/24) understood how to provide opportunities for students to record and share their initial ideas and predictions about phenomena. In their analysis, they recognized that the lesson provided opportunities for students to record their ideas and predictions. Here, Emily describes these aspects of the lesson plan, writing:

> At the beginning of the lesson, the students do have the opportunity to record their ideas and predictions. They fill out the Before the Investigation sheet which gives them the chance to draw a picture of what they would use to keep a cotton ball dry in the rain. They are also given the opportunity to fill out the Waterproofing Data Table which allows them to predict which items will keep a cotton ball dry in the rain. (Emily, Lesson plan analysis assignment 1)

In addition to identifying these strengths in the lesson plan, these preservice teachers also identified some weaknesses with regard to the indicator. They recognized that the lesson did not enable the students to share their ideas and predictions with others. They addressed this weakness by providing opportunities for students to share their ideas and predictions in small groups or as a whole class discussion, as shown in the following example:

> While the students did have the opportunity to record their ideas and predictions in their science journals, they did not get a chance to share their thoughts with the rest of their class, or even with a small group of peers. I think that the lesson should include either a whole class discussion…or they should engage in some pair or small group sharing time, during which they can talk to one another about their ideas and see what their peers think as well. Cooperative learning can be very beneficial in a lesson such as this one, since all of the students have such different prior experiences, and many of them may have different experiences that can contribute to their overall understanding of this scientific concept. (Chelsea,

Lesson plan analysis assignment 1)

Overall, the majority of the preservice teachers had a strong understanding of this indicator, recognizing if students had the opportunity to record and share their ideas and predictions and making adaptations to the lesson plan to compensate for any of its weaknesses.

Criterion 4—Providing Experiences with Phenomena

4a—Providing multiple experiences with phenomena. In their second lesson plan analysis assignment, over half of the preservice teachers (15/24) understood how to determine if students had the opportunity to experience the scientific phenomena in multiple ways, whether through first-hand or vicarious experiences or even through instructional representations. They demonstrated this understanding in their analysis of the second lesson plan, which involved engaging second and third graders in investigating the seed dispersal methods of different types of seeds. In their analysis, they asserted that the lesson only provided one experience with phenomena (the hands-on activity) and adapted the lesson to include another experience for students, as illustrated in Lisa's analysis:

> This lesson revolves around one experience with phenomena: the hands-on experiment with seeds. If I were to change this lesson, I would integrate a video or images of seeds in motion in everyday settings (a bur on a dog, helicopters). Students are more likely to make connections to a phenomena when they see it at play in its natural environment than in a lab (Oh! My dog gets burs in her fur…) (Lisa, Lesson plan analysis assignment 2)

Even though many of the preservice teachers understood this indicator, over a third of them (9/24) had an alternative understanding. They interpreted multiple experiences with phenomena to mean the different elements of the lesson plan (e.g., completing the worksheet, conducting the hands-on activity, participating in concluding discussion). For example, Shelley mistakenly pointed to different components of one experience with phenomena as evidence that the lesson plan provided students with multiple opportunities to experience the phenomena. She wrote, “Yes. Kids are possibly working outside for part of the lesson, they are interacting with the different types of seeds, they are experimenting with these materials in air, water, clothes, drawing pictures, filling in a chart” (Lesson plan analysis assignment 2). This excerpt shows that some of the preservice teachers did not understand what counted as an experience with phenomena. Failing to understand this pedagogical idea may result in missed opportunities for students to experience a range of phenomena, and in turn, see science ideas as having explanatory power.

4b—Having students record data. All of the preservice teachers understood how to provide opportunities for students to record their data. In their analysis, they recognized that the lesson plan asked students to complete a chart describing the experimental results of how different types of seeds traveled. Carmen exemplifies this understanding of the indicator, writing:

> Students are asked to create drawings of each type of seed that they received as well as write the name of the seed on their science worksheet. Students are also asked to record the test results of which phenomena can carry their seeds on their worksheets. I do feel that students are appropriately asked to record their data and observations throughout this lesson. (Carmen, Lesson plan analysis assignment 2)

Not only did the preservice teachers assess whether the lesson plan enabled students to record their data, but over a third of them (9/24) further analyzed the lesson plan to determine how well it did this. For example, some of the preservice teachers adapted the worksheet so that students would not only draw the different types of seeds that they tested but also describe the seeds' characteristics in words, as exemplified by Teresa, who wrote:

> On the student worksheet students are given a spot to draw pictures of the seeds and to record the way that the seed travels. I think that these are both crucial to the lesson. However, one thing that I would like to add to this sheet is a place to describe the characteristics of the seed. I would place this observation after drawing the seed. This way, students first really look at and study the seed and then must find words or descriptions for what they see. (Teresa, Lesson plan analysis assignment 2)

Overall, the preservice teachers understood how to provide structured opportunities for students to record their data, with some individuals further analyzing the quality of these data recording opportunities—exceeding the expectations of this indicator.

4c—Having students share and interpret their data. Most of the preservice teachers (20/24) demonstrated an understanding of how to engage students in sharing their results and looking for patterns in the data. In their analysis, they recognized that the lesson plan met this indicator, writing, for example:

> The lesson does provide students with the opportunity to share their results and look for patterns in the data. The section entitled 'Reflect and Discuss' allows them the opportunity to do so. The students share their results by talking about what they have noticed and learned from their experiments. The students are looking for patterns in the data by making connections between physical characteristics and likely dispersal type. (Emily, Lesson plan analysis assignment 2)

Additionally, about half of these preservice teachers (9/24) analyzed the lesson plan not only in terms of whether the lesson plan had students share and interpret their data but also how well they engaged students in these tasks. For example, Claire adapted the lesson to have each group of students share their results with the class in order to look for patterns in the data more systematically. She wrote:

> The lesson does not explicitly give opportunities for students to share their results and look for patterns in data; it does, however, give students a chance to share

> their overall conclusions in the large group. Having each group share their results with the whole-class might help the class look for patterns inherent across groups, and help students test their conclusions against those of their classmates. (Claire, Lesson plan analysis assignment 2)

In general, most of the preservice teachers demonstrated an understanding of how to engage students in sharing and interpreting their data. Even more, some individuals went beyond the stated indicator by also analyzing the quality of these tasks.

Criterion 5—Promoting Sense-Making

5a—Having students develop evidence-based explanations. Two-thirds of the preservice teachers (16/24) understood that constructing a scientific explanation entailed using evidence in support of a claim, and in turn, successfully recognized whether or not the lesson plan engaged students in this scientific practice. In their analysis, the preservice teachers noted that the whole class discussion at the end of the lesson provided students with the opportunity to use their investigation results to support their claims about how the seeds from their playground were dispersed. Michelle makes this observation in the following excerpt:

> During the final discussion, students are prompted to use their results and observations to support their idea about why they think the tree's seeds traveled the way they think. Students are held accountable for explaining their claims by using what they learned from their investigations. (Michelle, Lesson plan analysis assignment 2)

In addition to demonstrating this understanding, a third of the preservice teachers (8/24) further analyzed the lesson plan to see if it provided an opportunity for *every* student to develop a scientific explanation. For example, Debbie engaged in this additional analysis, writing:

> In the last part of the discussion the students are to ‘use the results from the investigation and their observations of the seeds' characteristics to explain why they think the tree's seeds travel in the way that they describe.' So this definitely

> encourages them to use the evidence they collected to support their claims/explanations! By having the whole class discussions it allows students to voice their explanations, however not all students will be heard (because of time constraints) so perhaps by having a journal for the students to write in would allow all students to participate in this part of the lesson. (Debbie, Lesson plan analysis assignment 2)

This example illustrates how the preservice teachers not only looked for opportunities for students to construct scientific explanations but that some of them also checked to see if every student had this opportunity—an expectation that surpassed the conditions of the stated indicator.

5b—Asking guiding questions to facilitate sense-making. Most of the preservice teachers (21/24) understood how to analyze the lesson plan for guiding questions to help students interpret their experiences with phenomena and connect them to scientific ideas. As written, the lesson plan did not provide the teacher with questions to guide students' understanding during the concluding discussion. These preservice teachers recognized this omission, but only half of them (12/24) modified the lesson plan in order to add discussion questions. The following example provides a set of questions that one preservice teacher developed. Karen wrote:

> There is no true list of questions that a teacher could use in a discussion. I think that this can be problematic for a teacher since discussions are sometimes difficult to manage and plan for. The lesson does provide the initial study question and two supplemental questions at the beginning of the lesson, however it does not include any final questions in the end of the discussion. I think that some questions that could be helpful include:
>
> - What did you notice in your observations of seeds?
>   - What did the seeds look like?
>   - What did they feel like?
>   - Did you notice any similarities or differences in your seeds?
> - What did you notice in your investigations?
>   - Were there any patterns you saw?
>   - What was challenging/difficult
> - Did you notice any patterns between seed shape/design and the way that it moved?

- What does that tell us about the seeds?
- Which seeds move by floating? Wind? Animals?

• Look at your first ideas about seeds: Is there anything you would change?
- Take the time to write down your new changes. How did your ideas change?
- Why did you change your ideas? What did you do in the activity that changed your activities? (Remember to use evidence for experiment).

(Karen, Lesson plan analysis assignment 2)[3]

The other preservice teachers who recognized that the lesson plan did not include guiding questions for the final discussion made no adaptations, even though the lesson plan analysis assignment asked them to make changes to the lesson plan if they identified any weaknesses in it. The task of designing discussion questions to guide an inquiry-based discussion may have been too difficult for them to complete. For example, Leah wrote, "The teacher is given little in the way of a list of questions, in order to help facilitate the discussion and the students' thinking" (Lesson plan analysis assignment 2). Similarly, Morgan noted the omission of discussion questions but did not adapt the lesson plan to compensate for this weakness, writing, "The lesson does not provide the teacher with a list of questions to help students interpret their experiences with phenomena and connect them to scientific ideas. The teacher has to come up with his or her own questions" (Lesson plan analysis assignment 2).

5c—Asking students to revisit their initial ideas. Most of the preservice teachers (22/24) understood how to analyze the lesson plan in terms of revisiting students' initial ideas. In their analysis, they recognized that it had students examine how their initial ideas have changed and in what ways. Emily illustrated this understanding in the following passage:

> The lesson does provide opportunities for students to revisit their initial ideas about the new content. At the end of the lesson, the teacher asks the students if

[3] Small typographical errors have been corrected to increase clarity.

> they have changed their mind about how they think trees got into their playground. This not only allows the students to revisit their initial ideas but also provides a way of making the lesson have more of a purpose. (Emily, Lesson plan analysis assignment 2)

Like Emily, most of the preservice teachers demonstrated an understanding of this indicator.

Criterion 6—Assessing Student Learning

6a—Assessing content understanding and inquiry abilities. In their third lesson plan analysis assignment, around one-third of the preservice teachers (9/24) understood how to analyze a lesson plan to see if it provided assessments that measured students' understanding of inquiry and content learning goals. The lesson plan for this assignment had fifth grade students learn about friction by testing how far a toy car can travel on a variety of surfaces. Its learning goals included developing students' content understandings of friction and their inquiry abilities, specifically with making predictions, recording results, and constructing evidence-based explanations. In their analysis of this lesson plan, the preservice teachers systematically checked to see if the lesson plan enabled the teacher to assess each learning goal and found that the learning goals were assessed through a combination of three different types of assessments—whole class discussion, teacher observation, and student worksheets. For example, Michelle explicitly detailed how the assessments aligned with the content and inquiry learning goals, writing:

> The lesson does provide teachers with assessments that provide them with opportunities to assess students' inquiry skills as well as students' understanding of science concepts. The science notebook page gives students a chance to make and record their predictions, as well as a place to record their actual findings so that at the end students can compare their findings with their predictions and revise their initial ideas. Additionally, the end of class discussion questions that ask why (the car stopped at different distances on the different surfaces) and ask students to use evidence to support their answers allow teachers to assess students' content understandings and ability to give explanations. (Michelle,

Lesson plan analysis assignment 3)

Even though some preservice teachers understood how to check for alignment between the learning goals and the assessments and correctly assessed the lesson plan based on this indicator, the majority of the preservice teachers (15/24) did not. The most common alternative understanding was the idea that the lesson plan simply needed to include an assessment. They assumed that the assessments would automatically be aligned with the learning goals, leading them not to articulate the connections between the assessments and learning goals. Amelia demonstrates this alternative understanding, writing, “[T]he lesson provides teachers with assessments to assess both science content and inquiry learning goals. These can be found under ‘Evidence.’ The teacher is to use the worksheet, class discussion, and observations to see if students meet the learning goals” (Lesson plan analysis assignment 3). Possessing this alternative understanding may result in missed opportunities to assess some learning goals, limiting what they as teachers will be able to say about what students understand and are able to do at the end of the lesson.

6b—Assessing each student’s understanding and abilities. Only three preservice teachers (3/24) understood the importance of having each student demonstrate both his or her content understanding and inquiry abilities. As written, the lesson plan allowed each student to make predictions and record results but not to develop explanations and express their content understandings. These preservice teachers addressed this weakness by adapting the worksheet to allow each student to record their content ideas and explanations. For example, Teresa wrote:

> I feel that the assessment does for the most part allow teachers to assess students' inquiry skills. They are assessed on their predictions when they record them on

> their notebook page and have to record their reasoning behind it. Students also have to actually carry out the experiment and record the information that they receive in a chart. The teacher can check this again by looking at the student notebook page. The only thing that the teacher may not be able to asses is the evidence based explanations that students make. At one point students are asked to share this in the whole class discussion, however, everyone will not get to share. There is also not a place on the worksheet for this. For this reason, I would add some of questions from discussion such as, 'Which surface had the most friction? What is your evidence?' onto the sheet. This way the teacher can view every student's response instead of just of a few. I also think that the teacher does a nice job of assessing students understanding of science ideas in the whole class discussion… However, I am not sure that she can assess all of her students' knowledge in this way. She cannot hear from every student or else the discussion would take forever. For this reason, I would add more of the discussion questions to the worksheet or have them write a journal entry after discussing some of the things that students learned. (Teresa, Lesson plan analysis assignment 3)

Aside from these three preservice teachers, the rest of the class (21/24) had an alternative understanding of this indicator. One perspective entailed the idea that it is only important for *each* student to express his or her *content* understandings but not his or her *inquiry* abilities. Thus, in their analysis, the preservice teachers with this perspective only commented on whether the lesson provided opportunities to assess each student's content understandings, writing, for example:

> As far as content is concerned, there is nothing really that lends itself to assessment of students' content learning. Another question could be added to the notebook page that asks students at the end of the activity why the cars went as far as they did or why they saw differences. The end of class discussion addresses content, but because it's a discussion it might not be representative of every student's thinking. Alternative ideas may go unnoticed because that student does not contribute to the discussion. (Susan, Lesson plan analysis assignment 3)

Focusing only on assessment of each student's content understandings may result in missed opportunities to assess each student's inquiry abilities, and in turn, to help each student improve their understandings of and abilities necessary to do inquiry.

Other preservice teachers who had an alternative understanding of this indicator assumed that use of the science worksheets would ensure that the teacher could assess students with regard to all of the learning goals. Thus, in their analysis, these preservice teachers asserted that the teacher could assess each student's content understanding and inquiry abilities by solely using the student worksheet. Chelsea demonstrates this alternative understanding, writing, "In the best way that it could, I think that yes, this lesson does allow each student to demonstrate his or her understanding and skills. Each student is responsible for his or her own student notebook page" (Lesson plan analysis assignment 3). Here, these preservice teachers did not realize that the worksheet only enabled the teacher to assess students' ability to make predictions and record results, not their content understandings and ability to develop scientific explanations. Assuming that teachers can rely exclusively on provided worksheets to assess all of their students' content understandings and inquiry abilities may result in missed opportunities for them to assess what students have learned in their science investigations.

6c—Asking students to apply their ideas to a new task. The majority of the preservice teachers (18/24) understood how to identify opportunities for students to apply their ideas to a new task or situation. In their analysis, they recognized that the lesson plan did not allow students to apply their newly developed ideas and thus adapted the lesson to compensate for this weakness. For example, Jackie suggested two ways to have students apply their ideas. She wrote:

> Something that I think this lesson plan is lacking is an assessment that requires students to apply their ideas to a new task or situation… Giving students examples of a few other surfaces and asking them to predict how far the car would go on those surfaces and to support it with information they had learned that day would work. Another way would be to give students a scenario and have them describe how friction played a role in the situation. (Jackie, Lesson plan analysis assignment 3)

Most preservice teachers displayed an understanding of this indicator.

Criterion 7—Making Science Accessible for All Students

7a—Attending to the needs of individual students. Only four preservice teachers (4/24) understood how to consider the needs of individual students or groups of students in their analysis. They modified the lesson plan to accommodate for the needs of specific groups of students, including students with disabilities, English language learners, and special needs students. For example, Amelia addressed the needs of two particular groups of students, writing:

> The lesson does not offer ideas for paring down the lesson for students with disabilities or making the lesson more challenging for high-achieving students. I would have an alternative worksheet for or assign student buddies to students with disabilities, depending on the nature of the disability. I would also have a list of more challenging questions about the investigation for high-achieving students to consider or ask them to research friction on the computer if they finished early. They would need to find two interesting facts about friction to share with the rest of the class during the wrap-up discussion. (Amelia, Lesson plan analysis assignment 3)

Aside from these preservice teachers, the rest of the class (20/24) had an alternative understanding of this indicator. They analyzed the lesson plan to see if the teacher had the opportunity to help students, in general, rather than specific students or groups of students. Thus, in their analysis, they stated that the teacher had the opportunity to attend to the needs of individual students by modeling how to do the experiment, enabling students to work in groups, or circulating while students worked on the experiment, as illustrated in the following example:

> I think so, the fact that the teacher models the experiment first giving students explicitly what they need to do sets them up to succeed…Furthermore, small group work is great and allows students to help each other out. The teacher can move around between the groups to help with what their doing. (Melanie, Lesson plan analysis assignment 3)

This excerpt exemplifies the alternative understanding that most of the preservice teachers had with regard to this indicator. Focusing only on a class as a whole rather than on individual students may result in missed opportunities for them as teachers to attend to the needs of every student and thus to help all students experience success in learning about science.

7b—Connecting science ideas to personal/cultural experiences. Most of the preservice teachers (19/24) understood what it meant to analyze a lesson plan to see if it allowed students to make connections between the science ideas and their personal, cultural, and social experiences. In analyzing the lesson plan, they recognized that students did not have an opportunity to make these connections and thus adapted the lesson to compensate for this weakness. The preservice teachers made a variety of adaptations. Some suggested adding a question that asked students to provide examples of when they have experienced friction in their own lives. Others suggested doing the extension activity with shoes at the end of the lesson or having students write as homework about examples of friction in their homes, as illustrated in Mia’s analysis:

> [T]he 'extending the ideas' section could count as this because it talks bout different types of shoes. Shoes can look very different in different cultures and places around the world so maybe if they actually did this section; it would tie in kids’ personal connections. I think there could [be] a homework sheet for this experiment that says 'Go home and write down three examples where you see friction working in your house'. This way kids could make a more personal connection. (Mia, Lesson plan analysis assignment 3)

Still others suggested that students write a story about an experience they have had with friction and share their story with the class. Jackie described this modification in her analysis, writing:

> There also was not a lot of opportunity in this lesson for students to make connections between the scientific ideas they were generating and their own

> experiences. A cross curricular activity that might be meaningful for students is to have them write a short story about an experience they had where friction played a role. This would force students to think about why understanding friction is important and they will realize that it is something that they are constantly experiencing. If students were able to share these stories, it would show that in the classroom everyone's experiences are important and valued, making a welcoming environment for all students. (Jackie, Lesson plan analysis assignment 3)

These typical examples show that the preservice teachers tended to understand how to help students connect science ideas with their own personal, social, and cultural experiences.

7c—Making scientific terminology accessible to all students. Only a fourth of the preservice teachers (6/24) understood how to make scientific terms accessible to all students. In their analysis, they recognized that not all of the students would have the same familiarity with the term ‘friction.’ As the lesson was written, it introduced the term at the beginning of the lesson and then jumped into an investigation on friction. These preservice teachers modified the lesson to provide students with additional opportunities to think about the meaning of this term before completing the investigation, as illustrated in the following excerpt:

> No, I don't believe it does….It may also be helpful for students who are not familiar with the scientific terminology to see an example of the effects of friction, may be through a video or a teacher-led experiment before students make their predictions because they will be able to understand friction better. (Jessica, Lesson plan analysis assignment 3)

The rest of the class (18/24) had an alternative understanding of this indicator. They assumed that providing definitions at the beginning of the lesson necessarily made scientific terms accessible to all students. Thus, in their analysis, these preservice teachers thought that the lesson plan made the terminology accessible to students by providing them with the definition for ‘friction’ before investigating the science concept.

Emily made this assertion in her analysis, writing:

> This lesson helps teachers make scientific terminology accessible to all students. At the beginning of the lesson…[the teacher] tells them that friction is 'a force (or pull) that allows down moving objects.' In this way, she is making certain scientific terminology available for all students in that she is reciting the definition to the whole class. (Emily, Lesson plan analysis assignment 3)

Most of the preservice teachers thought that students simply needed to hear a definition in order to develop an understanding of a particular science concept. Possessing this alternative understanding may lead teachers to alienate students who may not be familiar with the norms of scientific language, thus impacting students' ability to experience success in learning science.

Summary

The preservice teachers demonstrated adequate understanding and application of five of the seven reform-based criteria. The two criteria with which they tended to struggle the most included 'assessing student learning' and 'making science accessible to all students.' For most of the reform-based criteria, the preservice teachers tended to demonstrate both accurate and alternative understandings of the individual indicators. However, for a few of the indicators, the majority of the preservice teachers not only correctly applied the indicators in their analysis but also analyzed the lesson plan along other dimensions related to the indicators, autonomously engaging in a more thorough analysis than required by the assignments.

Lesson Plan Analysis Assignments:
Understanding and Application of a Repeated Reform-Based Criterion

The preservice teachers repeatedly applied one criterion across the lesson plan analysis assignments in order to determine if applying the same criterion using different lesson plans might improve their understanding and application of the criterion. This criterion focused on 'eliciting students' initial ideas and predictions.' A repeated measures analysis revealed that the assignment scores differed significantly across time for this criterion, $F(1.90, 43.63) = 34.61$, $p = .000$, with a large effect size (partial eta-squared = .60). Post hoc pairwise comparisons, corrected using Bonferroni adjustments, revealed a significant difference in mean scores for criterion 3 across all three assignments. The preservice teachers scored significantly lower on the second lesson plan analysis assignment, in comparison to the first assignment, but scored significantly higher on the third assignment, in comparison to the first two assignments (see Table 4.3 for mean scores).

Table 4.3
Mean Scores for Criterion 3 Across Lesson Plan Analysis Assignments

Lesson Plan Analysis Assignment	Mean Score [a]	SD	Depth of Understanding [b]
1	1.92	0.83	Adequate
2	0.54	1.02	Weak or partial
3	2.50	0.72	Strong

[a] Score represents the number of indicators addressed by each preservice teacher for each criterion; maximum score = 3.00. [b] 0.00 - 0.49 = No understanding; 0.50 - 1.49 = Weak or partial understanding; 1.50 – 2.49 = Adequate understanding; 2.50 – 3.00 = Strong understanding

The preservice teachers varied in their understanding and application of the individual indicators of criterion 3, as illustrated in Table 4.4. A qualitative description of their understanding of this criterion across time is presented below.

Table 4.4
Number of Preservice Teachers Addressing Each Indicator of Criterion 3 Across Lesson Plan Analysis Assignments

Indicators for Criterion 3	Number of Preservice Teachers Who Demonstrated Understanding of Indicator (%)		
	Assignment 1	Assignment 2	Assignment 3
3a—Eliciting ideas/predictions	16 (67%)	5 (21%)	21 (88%)
3b—Eliciting explanations for ideas/predictions	16 (67%)	5 (21%)	18 (75%)
3c—Recording and sharing ideas/predictions	16 (67%)	3 (13%)	20 (83%)

As previously described, two-thirds of the preservice teachers correctly applied the indicators for 'eliciting students' initial ideas and predictions' in the first lesson plan analysis, demonstrating adequate understanding and application of criterion 3. The lesson plan in the second assignment dealing with seed dispersal contained different strengths and weaknesses from that of the first lesson plan with regard to this criterion. One difference was that the second lesson plan did not provide an opportunity for students to make predictions about how the different seed types might be dispersed. However, only five preservice teachers identified this omission in the lesson plan, writing, for example:

> I did notice the teacher doesn't have them predict how the seeds they are working with will travel. They are directed to draw them and record their names, but there isn't a time where they predict how it disperses based on their characteristics. I would change this part by having the students observe the seeds they are given, then make a prediction of how they travel either by wind, water, or animal (hitchhiker), and then have them explain why they chose that option. (Melanie, Lesson plan analysis assignment 2)

Aside from this handful of preservice teachers, the rest of the class did not recognize that the lesson plan failed to elicit students' predictions because they had an alternative understanding of what a prediction is. These preservice teachers viewed students' predictions about the phenomena as the same thing as their initial ideas about the new content. As a result, these individuals mistakenly asserted that the lesson plan elicited both students' initials ideas and predictions. For example, Debbie incorrectly pointed to the opening discussion as the place where the teacher could elicit both students' ideas and predictions. She wrote:

> The two questions that the teacher asks about where new plants grow and why new plants do not grow under a parent plant allows the teacher to elicit further ideas about the new content, as well as having students make predictions during this discussion on the new content. (Debbie, Lesson plan analysis assignment 2)

This example typifies how most of the preservice teachers were unable to distinguish between eliciting students' initial ideas and their predictions. They did not understand that predictions deal specifically with students' ideas about what they think the results from an experiment or investigation will be. As a result, the preservice teachers incorrectly applied all three indicators with regard to students' predictions about the phenomena. Thus, the second assignment revealed that most of the preservice teachers had a weak understanding of criterion 3.

Like the other two lesson plans, the lesson plan for the third assignment dealing with friction also emphasized different strengths and weaknesses with regard to this criterion. It elicited students' initial ideas about the new content and predictions about the phenomena at the beginning of the lesson. Most of the preservice teachers (21/24) identified these places in the lesson plan, as illustrated by Ashley's analysis:

> The teacher does elicit students' ideas about the new content (Friction). In the getting started section of the lesson plan the teacher writes the word 'friction' on the boards and asks students to share what they think the word might mean. After they come up with ideas the teacher tells them what friction is. She allows the students to feel the three different surfaces they will be using in their experiment and has them make predictions about on which surface the toy car will travel the longest distance and the shortest distance. This allows students to make predictions about the phenomena. (Ashley, Lesson plan analysis assignment 3)

The third lesson plan also asked students to give explanations for their predictions but not for their initial ideas. Three-quarters of the preservice teachers (18/24) successfully identified when students had the opportunity to give explanations and when they did not. Michelle illustrated this understanding and modified the lesson plan to compensate for its weakness, writing:

> At the beginning of the lesson the students are told to give explanations for their predictions about the phenomena, but are not asked for explanations about friction in general. The teacher should tell students to be prepared to explain 'why' they think friction is what they share with the class. Students can mention what leads them to believe friction exists, or can explain where they have seen friction working in their everyday lives. (Michelle, Lesson plan analysis assignment 3)

Finally, the third lesson plan asked students to share their initial ideas but not their predictions and to record their predictions but not their initial ideas. Again, most of the preservice teachers (20/24) pinpointed these strengths and weaknesses in the lesson plan and made a variety of adaptations to address these weaknesses, writing, for example:

> The lesson does not allow for the students to record their ideas about the new content ‘friction’ but does allow for students (but not all) to share their ideas. The teacher is to ‘write the word ‘friction’ on the board and then ask students what they think this word means.’ I would make sure to include opportunities for students to not only share their ideas about the word friction but perhaps be able to record their ideas in their notebooks. The lesson does allow for students to record their predictions on their Notebook pages and explanations but it does not say for the students to share them with the class. I would like to add a short discussion after the students record their predictions to give them the opportunity to share their predictions with the rest of the class. (Debbie, Lesson plan analysis assignment 3)

Overall, by the third assignment, the majority of the preservice teachers correctly applied all three indicators, demonstrating strong understanding and application of criterion 3.

Even more, unlike the first two assignments, half of the preservice teachers (12/24) in the third lesson plan analysis assignment not only attended to the indicators of this criterion but also analyzed the lesson plan to determine *how well* it elicited students’ ideas and predictions. For example, some of the preservice teachers not only analyzed the lesson plan to see if it allowed students to share their initial ideas and predictions but also analyzed it to see if *every* student had the opportunity to share. The following excerpt shows how Shelley replaced the beginning whole class discussion with a pair-share activity in order to allow more students to share their initial ideas. She wrote:

> The teacher only allows for a few students to share their initial ideas about friction. Although it is true you do not have time for every student to share their thoughts, it would be beneficial for the teacher to allow students to share with one another these ideas. This gives all students the chance to express their thoughts. (Shelley, Lesson plan analysis assignment 3)

Additionally, other preservice teachers not only analyzed the lesson plan in terms of whether it elicited students' ideas and predictions but also in terms of the effectiveness of the elicitation strategies. For example, Kelly decided to elicit students' ideas about friction by providing them with an example to discuss rather than simply asking them what they think friction is. She wrote:

> The teacher does ask students what they think friction might be, which could be considered eliciting ideas about the content. However, I think he or she could do a better job at this by asking students to think about friction at work, not just the textbook definition of the word. To do this, he or she could give a clear example of friction at work, and ask what forces might be working in that case to see if students have any idea about friction before the word is given to them in a certain context. (Kelly, Lesson plan analysis assignment 3)

These excerpts show that some individuals not only attended to the indicators of criterion 3 but also examined the quality of the strategies for eliciting students' initial ideas and predictions, going beyond the expectations of the stated indicators in their analysis. Overall, by the third lesson plan analysis assignment, the preservice teachers demonstrated an accurate understanding of criterion 3 and often exceeded expectations.

Summary

The preservice teachers demonstrated adequate understanding and application of criterion 3 in their initial analysis. However, their second analysis of a lesson plan, which highlighted different strengths and weaknesses from the first lesson plan that they analyzed, revealed that the preservice teachers did not have a complete understanding of this criterion, specifically of the meaning of “prediction.” By the final analysis, the preservice teachers had demonstrated a strong understanding of criterion 3—the highest level of understanding attained among all of the criteria.

Overview of Results for Reflective Teaching Assignments

The second main section of this chapter addresses the following analysis question: *When asked to choose criteria and apply them in their critique and adaptation of their own lesson plans, what criteria do preservice teachers use, and how well do their analyses address the reform-based criteria?* To answer this question, I analyzed the preservice teachers’ reflective teaching assignments with regard to their criteria choices and the extent to which they addressed the reform-based criteria in their analyses.

Results show that the preservice teachers tended to choose the reform-based criteria over their own criteria. Specifically, most of the preservice teachers chose to apply the criterion that had been repeated across the lesson plan analysis assignment—‘eliciting students’ initial ideas and predictions’—in both of the reflective teaching assignments. In contrast, fewer preservice teachers applied any of the other reform-based criteria. With regard to how well their lesson plans addressed the reform-based criteria, the preservice teachers demonstrated adequate understanding and application of only two of the seven reform-based criteria—‘attending to learning goals’ and ‘establishing a sense of purpose.' They demonstrated weak or partial understanding and application of the rest of the criteria either because they misapplied the criteria in their analyses, thereby demonstrating alternative understandings, or simply disregarded the criteria as they revised their lesson plans.

Reflective Teaching Assignments: Criteria Choices

The preservice teachers completed two reflective teaching assignments during the science methods course. Like the lesson plan analysis assignments, the reflective teaching assignments asked the preservice teachers to apply *three* criteria (with indicators) in their analyses, providing them a scaffolded experience with critiquing and adapting lesson plans. The assignments then asked them to develop a revised lesson plan based on their analysis of their original lesson plan. However, unlike the lesson plan analysis assignments, the reflective teaching assignments allowed the preservice teachers to choose their own criteria and indicators for their analysis. The assignments also had the preservice teachers use lesson plans that they received from their cooperating teacher or that they designed themselves. The preservice teachers were responsible for teaching these lessons in their field placements.

With regard to their criteria choices, the preservice teachers tended to choose the reform-based criteria more often than their own criteria, that is, criteria other than the reform-based criteria. This difference in their criteria choices was statistically significant for both assignments, with roughly two of their three criteria choices focused on the reform-based criteria (see Table 4.5).

Table 4.5

Use of Reform-Based Criteria Versus Own Criteria Within Reflective Teaching Assignments

RT Assignment	Reform-Based Criteria		Own Criteria		*t*-Value [b]	Effect Size [c]
	Mean [a]	SD	Mean	SD		
1	2.13	0.74	0.88	0.74	4.133***	1.69
2	2.42	0.83	0.83	0.83	5.567***	1.92

[a] Mean number of criteria applied by each preservice teacher in their reflective teaching assignment. The assignment asked preservice teachers to select a total of three criteria for analysis. [b] Two-tailed paired samples t-test, $df = 23$. [c] Effect size is calculated by dividing the difference between the mean scores by the average of the standard deviations.

* $p < .05$, ** $p < 0.01$, *** $p < 0.001$

By the first reflective teaching assignment, the preservice teachers had learned about three reform-based criteria, and by the second reflective teaching assignment, they had learned about all seven of them. With regard to the *reform-based* criteria, a repeated measures analysis revealed that their choices differed significantly among the three reform-based criteria in the first reflective teaching assignment [$F(1.95, 44.77) = 6.66$, $p = .003$, partial eta-squared = .23)] and among the seven reform-based criteria in the second reflective teaching assignment [$F(4.58, 105.35) = 5.83$, $p = .000$, partial eta-squared = .20]. For both assignments, pairwise comparisons with error rate corrections showed that the preservice teachers tended to choose criterion 3—'eliciting students' initial ideas and predictions'—significantly more often than the other reform-based criteria when completing their analyses (see Table 4.6). This criterion was the same criterion that was repeated across the lesson plan analysis assignments. More than three-fourths of the preservice teachers applied criterion 3 in their analysis of their lesson plans for both assignments. In contrast, less than half specifically focused on any of the other reform-based criteria in their analyses.

Table 4.6

Reform-Based Criteria Choices within Reflective Teaching Assignments

Reform-Based Criteria	RT Assignment 1		RT Assignment 2	
	Mean [a]	SD	Mean	SD
1-Learning goals	0.50	0.51	0.42	0.50
2-Purpose	0.38	0.50	0.25	0.44
3-Elicit ideas	0.83	0.38	0.79	0.42
4-Experiencing phenomena	n/a	n/a	0.25	0.44
5-Sense-making	n/a	n/a	0.25	0.44
6-Assessment	n/a	n/a	0.38	0.50
7-Accessible science	n/a	n/a	0.08	0.28

[a] Score represents whether each preservice teacher attended to the criterion in their analysis (0 = did not attend; 1 = did attend); maximum score = 1.0.
Note. n = 24 preservice teachers

With regard to their *own* criteria, the preservice teachers tended to focus primarily on classroom management. In the first assignment almost half of the preservice teachers (11/24) identified strengths and weaknesses with regard to this criterion, and nearly a third (7/24) did so in the second assignment. In their reflective teaching assignments, the preservice teachers provided a variety of reasons explaining why they thought it was important to attend to classroom management in their analyses. Some had to negotiate time constraints and a large class size during their lesson, motivating them to focus on management in order to maximize instructional time and student learning. Others mentioned that their lesson included frequent transitions and numerous supplies, leading them to think about ways to prevent chaos during their lesson. For example, Amelia's lesson included a "hands-on activity" and "frequent switches between individual and group work," leading her to think about how she might "move materials and transition efficiently" (Reflective teaching assignment 1). Still others considered how they would manage specific behavioral issues within their own classroom. The final reason the preservice teachers gave for focusing on classroom management was to develop their skills as new teachers. For example, Karen explained that "new teachers require more planning and practice to handle management issues" than experienced teachers who are more adept at "making changing on the spot to account for management issues" (Reflective teaching assignment 2).

Summary

The preservice teachers tended to choose the reform-based criteria over their own criteria in their analysis of their own lesson plans. However, the number of preservice teachers focusing on each of the reform-based criteria differed significantly. Most of the preservice teachers applied criterion 3 in their analysis, but fewer applied any of the other reform-based criteria. With regard to their own criteria choices, most of the preservice teachers focused on classroom management, providing a variety of reasons for applying this criterion.

Reflective Teaching Assignments:
Understanding and Application of the Reform-Based Criteria

I analyzed the preservice teachers' revised lesson plans to determine how well they addressed the indicators of each reform-based criterion, regardless of what criteria the preservice teachers applied in their analysis. In other words, I looked to see how consistent their revised lesson plans were with the different dimensions of reform-based science teaching. A repeated measures analysis revealed that the mean scores for the first reflective teaching assignment differed significantly among the three reform-based criteria across all of the preservice teachers, $F(1.90, 43.67) = 5.03$, $p = .012$, with a small effect size (partial eta-squared = .18). With error rate corrections, follow up comparisons revealed that the preservice teachers demonstrated a stronger understanding of criteria 1 and 2 than criterion 3 when completing their analysis of their own lesson plans (see 'All Preservice Teachers' column in Table 4.7 for means).

Table 4.7
Mean Scores for Each Reform-Based Criterion in Reflective Teaching Assignment 1

Criterion	All Preservice Teachers				Only Those Who Explicitly Applied Criterion			
	n	Mean Score [a]	*SD*	Depth of understanding [b]	*n*	Mean Score [a]	*SD*	Depth of understanding [b]
1-Learning goals	24	2.10	0.75	Adequate	12	2.04	0.72	Adequate
2-Purpose	24	2.00	0.51	Adequate	9	1.94	0.53	Adequate
3-Eliciting ideas	24	1.58	0.69	Adequate	20	1.83	0.34	Adequate

[a] Score represents the number of indicators addressed by each preservice teacher for each criterion; maximum score = 3.0. [b] 0.00 - 0.49 = No understanding; 0.50 - 1.49 = Weak or partial understanding; 1.50 – 2.49 = Adequate understanding; 2.50 – 3.00 = Strong understanding

Among only the preservice teachers who applied the criteria in their analysis, their mean scores were only slightly higher or roughly the same (see ‘Only Those Who Explicitly Applied Criterion’ column in Table 4.7 for means), in comparison to the scores for the whole class. These scores need to be interpreted in light of the fact that not all of the preservice teachers who applied the criteria used the indicators from the lesson plan analysis assignments. In fact, a third of these individuals modified or omitted indicators when completing their analysis. For example, one of the original indicators for criterion 3 entailed having students give explanations for their initial ideas and predictions. However, Leah chose not to include this indicator, as shown in her list of indicators:

> 1) Are students given the opportunity to formulate their ideas about the topic? 2) Are students given the opportunity to make predictions about the lesson’s final results? 3) Are students given the opportunity to share their ideas/predictions with the class? 4) Are students given the opportunity to write down their ideas/predictions? (Leah, Reflective teaching assignment 1)

The modifications that the preservice teachers made to the indicators may have negatively impacted their scores, resulting in marginal differences in mean scores between the whole class and individuals who specifically applied the criteria.

With regard to their second reflective teaching assignment, a repeated measures analysis showed that the mean scores differed significantly among the seven reform-based criteria across the class, $F(4.51, 103.79) = 10.01$, $p = .000$, with a moderate effect size (partial eta-squared = .30). Like the first reflective teaching assignment, pairwise comparisons showed that the preservice teachers demonstrated a stronger understanding of criteria 1 and 2 than the rest of the reform-based criteria (see Table 4.8 for means). In comparison to the scores from the entire class, the scores from the preservice teachers who specifically applied the criteria in their analysis tended to be only slightly higher or roughly the same (see Table 4.8). However, as noted above, some of the preservice teachers had modified or omitted the indicators that accompanied the reform-based criteria. In fact, in the second reflective teaching assignment, nearly half of the preservice teachers revised at least some of the indicators. For example, Mia applied criterion 5—'promoting student sense-making'—but replaced two of the three original indicators with her own. The original indicators for fostering sense-making entailed engaging students in developing evidence-explanations, asking discussion questions to facilitate interpretation, and asking students to revisit their initial ideas, but Mia applied the following indicators in her analysis: "Does the teacher ask facilitating questions to draw the knowledge out of the students?...Does the teacher allow chances for all of the students to participate in the discussion?...Does the discussion run smoothly and is mainly student led?" (Reflective teaching assignment 2).

Table 4.8
Mean Scores for Each Reform-Based Criterion in Reflective Teaching Assignment 2

Criterion	All Preservice Teachers				Only Those Who Explicitly Applied Criterion			
	n	Mean Score[a]	*SD*	Depth of understanding[b]	*n*	Mean Score[a]	*SD*	Depth of understanding[b]
1-Goals	24	2.02	0.52	Adequate	10	1.95	0.37	Adequate
2-Purpose	24	2.19	0.76	Adequate	6	2.42	0.49	Adequate
3-Elicit ideas	24	1.29	0.71	Weak/partial	19	1.42	0.65	Weak/partial
4-Phenomena	24	1.13	1.15	Weak/partial	6	1.80	1.10	Adequate
5-Sensemaking	24	1.08	1.02	Weak/partial	6	1.33	1.03	Weak/partial
6-Assessment	24	1.35	0.94	Weak/partial	9	1.22	0.79	Weak/partial
7-Accessibility	24	1.04	0.81	Weak/partial	2	1.50	0.71	Adequate

[a] Score represents the number of indicators addressed by each preservice teacher for each criterion; maximum score = 3.0. [b] 0.00 - 0.49 = No understanding; 0.50 - 1.49 = Weak or partial understanding; 1.50 – 2.49 = Adequate understanding; 2.50 – 3.00 = Strong understanding

With regard to specific indicators of each criterion, the preservice teachers varied in how well they addressed them. Findings show that at least a few preservice teachers were able to apply each indicator in their analysis of their own lesson plans. However, the majority of the preservice teachers accurately addressed only a few of the indicators across both analyses. These indicators pertained to criteria 1—'attending to learning goals'—and 2—'establishing a sense of purpose.' Why might have this been the case? As previously mentioned, more than half of the preservice teachers did not even apply most of the reform-based criteria in their analysis, resulting in missed opportunities to improve their lesson plans. (This occurred even though the assignment itself prompted the preservice teachers to think about most of the criteria as they developed their revised lesson plan. See Appendix C for the connections between the assignment and the criteria.) Additionally, some of the preservice teachers who did apply the reform-based criteria did not address all of their indicators because they modified or omitted them in their analysis. Still other preservice teachers applied the reform-based criteria as-is but simply demonstrated alternative understandings of the indicators. Tables 4.9 and 4.10

show which indicators the preservice teachers tended to apply correctly and which indicators they frequently misapplied or did not attend to in the first and second reflective teaching assignments, respectively.

Table 4.9
Number of Preservice Teachers Addressing Indicators within Reflective Teaching Assignment 1

Criterion/Indicator	Individuals Who Addressed Indicator		
	Frequency[a]	Percentage	Category[b]
1—Attending to learning goals			
1a—Including content/inquiry learning goals	11	46%	Some
1b—Connecting learning goals to standards	17	71%	Most
1c—Aligning lesson to learning goals	20	83%	Most
2—Establishing a sense of purpose			
2a—Making the purpose explicit to students	21	88%	Most
2b—Making the purpose meaningful	6	25%	Few
2c—Connecting purpose to previous lessons	22	92%	Most
3—Eliciting students' initial ideas/predictions			
3a—Eliciting ideas/predictions at start of lesson	7	29%	Few
3b—Eliciting explanations for ideas/predictions	9	38%	Some
3c—Having students record/share ideas	18	75%	Most

[a] Out of n = 24 preservice teachers

[b] Most = Two-thirds or more of the preservice teachers address indicator; Some = Greater than one-third but less than two-thirds of the preservice teachers address indicator; Few = One-third or fewer preservice teachers address indicator.

Table 4.10
Number of Preservice Teachers Addressing Indicators within Reflective Teaching Assignment 2

Criterion/Indicator	Individuals Who Addressed Indicator		
	Frequency[a]	Percentage	Category[b]
1—Attending to learning goals			
1a—Including content/inquiry learning goals	8	33%	Few
1b—Connecting learning goals to standards	16	67%	Most
1c—Aligning lesson to learning goals	22	92%	Most
2—Establishing a sense of purpose			
2a—Making the purpose explicit to students	22	92%	Most
2b—Making the purpose meaningful	10	42%	Some
2c—Connecting purpose to previous lessons	20	83%	Most
3—Eliciting students' initial ideas/predictions			
3a—Eliciting ideas/predictions at start of lesson	5	21%	Few
3b—Eliciting explanations for ideas/predictions	4	17%	Some
3c—Having students record/share ideas	13	54%	Some
4—Providing experiences with phenomena			
4a—Providing multiple experiences	7	29%	Few
4b—Having students record data	11	46%	Some
4c—Having students share/interpret their data	10	42%	Some
5—Promoting sense-making			
5a—Having students develop explanations	6	25%	Few
5b—Asking guiding questions to discussion	10	42%	Some
5c—Asking students to revisit their initial ideas	10	42%	Some
6—Assessing student learning			
6a—Assessing understanding/inquiry abilities	8	33%	Few
6b—Assessing each student's ideas and abilities	10	42%	Some
6c—Asking students to apply ideas to new tasks	6	25%	Few
7—Making science accessible for all students			
7a—Attending to needs of individual students	7	29%	Few
7b—Connecting to personal experiences	5	21%	Few
7c—Making scientific terms accessible to all	11	46%	Some

[a] Out of n = 24 preservice teachers
[b] Most = Two-thirds or more of the preservice teachers address indicator; Some = Greater than one-third but less than two-thirds of the preservice teachers address indicator; Few = One-third or fewer preservice teachers address indicator.

Though some of the preservice teachers demonstrated strengths in their understanding and application of the indicators, this section does not expound upon these strengths since evidence of the preservice teachers correctly applying each indicator is provided in the section about the findings from the lesson plan analysis assignments.

Instead, this section builds upon the findings from the lesson plan analysis assignments dealing with preservice teachers' alternative understandings of the reform-based criteria. Below are examples from their reflective teaching assignments illustrating the indicators with which the preservice teachers tended to struggle, along with descriptions of the alternative understandings underlying those unmet indicators. These descriptions also note which alternative ideas were similar to and different from the alternative ideas that emerged from the lesson plan analysis assignments.[4]

Criterion 1—Attending to Learning Goals

1a—Including inquiry and content learning goals. The reflective teaching assignments reminded the preservice teachers to include both content and inquiry learning goals in their lesson plan. The science methods course described inquiry in terms of the practices of questioning and predicting, gathering evidence and using it to develop scientific explanations, and communicating and justifying explanations (NRC, 2000). However, many of the preservice teachers (RT1: 13/24; RT2: 16/24) did not include learning goals that emphasized these inquiry practices, even though the assignment asked them to include both content and inquiry learning goals. For example, Debbie analyzed her learning goals as part of her analysis to determine whether they addressed both content and inquiry and came up with the following goals, writing:

- Students will be able to develop an understanding that science is a human endeavor by reading about what paleontologists study.

[4] I was only able to discern the preservice teachers' alternative understandings of the criteria if they applied the criteria in the lesson plan analysis part of the reflective teaching assignment and demonstrated misapplication of the criteria. Otherwise, I did not have access to the rationales that the preservice teachers used to justify their analyses since only the lesson plan analysis tasks, not the revised lesson plans, provided this additional information. Thus, I was not able to articulate patterns in alternative understandings for criteria that few preservice teachers chose to focus on in their analysis and for criteria that the preservice teachers tended to correctly apply in their analysis.

- Students will develop an understanding that dinosaurs are like other organisms that are alive today. (Debbie, Reflective teaching assignment 1—revised lesson plan)

Neither of these learning goals actually addressed inquiry. Examining the preservice teachers' analysis tasks revealed two alternative understandings underlying the misapplication of this indicator. Like in the lesson plan analysis assignments, some of the preservice teachers evaluated the lesson plan, rather than the learning goals, for inquiry. For example, Debbie demonstrated this alternative understanding in her analysis of her lesson plan, writing:

> This lesson does address the science content of dinosaurs, but it is lacking to address inquiry. As you will read, I have created a journal page for the students to do to make the lesson more inquiry based; obviously the discussions (and the questions I will ask) we will have (as you will read) will also help to make the lesson inquiry based as well. (Debbie, Reflective teaching assignment 1—lesson plan analysis task)

Here, Debbie analyzed her lesson plan, not its learning goals, to see if it addressed inquiry, leading her to omit inquiry learning goals in her revised lesson plan, as shown above. Failing to articulate inquiry learning goals may result in missed opportunities to hold students accountable for developing particular inquiry understandings and abilities.

Others struggled with including inquiry learning goals because they possessed an alternative understanding of inquiry. For example, Emily, Carmen, and Claire taught the same lesson plan and all three of them decided to keep the same learning goals from the original lesson plan in their revised lesson plan, after applying this indicator in their analysis. They wrote:

> Students will be able to:
> - Learn and discuss ideas about how clouds are made.
> - Become familiar with different cloud types on a chart.
> - Make models of the three basic cloud shapes.
>
> (Reflective teaching assignment 1—revised lesson plan)

These preservice teachers each stated that the first two learning goals addressed content and the third one addressed inquiry, as illustrated in Emily's lesson plan analysis:

> As far as content is concerned, the learning goal of discussing ideas about how clouds are made and becoming familiar with different cloud types on a chart both involve teaching children about the necessary content. The learning goal of making models of the three basic cloud shapes addresses inquiry because the teacher doesn't give the class an example of what their picture should look like. Rather, the kids are told what cloud shapes to make and have to make them on their own. (Emily, Reflective teaching assignment 1—lesson plan analysis task)

In this lesson plan students used cotton balls to illustrate different cloud types, but the preservice teachers told the students how to make each cloud type, as shown in Emily's lesson plan:

> I will give them clues on how to form these clouds and also post a chart up of these clues at the front of the room to remind the children while they are working. For cumulus clouds, I will tell them to glue some cotton balls down in the shape of an animal. For cirrus clouds, I will tell them to pull a cotton ball into long threads before gluing it down and for stratus clouds, I will tell them to glue the square or circular cotton pads down. (Emily, Reflective teaching assignment 1—revised lesson plan)

Emily, as well as Carmen and Claire, mistakenly thought that having their students make these cloud models would provide them with the opportunity to engage in inquiry. Possessing an inaccurate understanding of inquiry may result in missed opportunities to engage students in genuine inquiry and thus to develop their inquiry understandings and abilities.

Criterion 2—Establishing a Sense of Purpose

2b—Making the purpose meaningful to students. The majority of the preservice teachers (RT1: 18/24; RT2: 14/24) struggled with helping students see the purpose of the lesson as meaningful and relevant to their lives. For example, Amelia's lesson helped students learn about static electricity but did not help them understand how this scientific concept related to the real world, even though she applied this indicator in her analysis (Reflective teaching assignment 1—revised lesson plan). Preservice teachers, like Amelia, who did not help students see the purpose as meaningful tended to demonstrate one main alternative understanding with regard to this indicator. Like in the lesson plan analysis assignments, they evaluated the lesson purpose to see if it would be meaningful to students rather than the lesson plan itself to see if helped students see the purpose as meaningful. Amelia illustrated this alternative understanding in her lesson plan analysis, writing:

> The subject of static electricity is meaningful to students because students encounter this phenomena on a daily basis in the forms of shocks from the McDonald's Playland slides, the wrappers of their juice box straws "sticking" to their hands, and many others. (Amelia, Reflective teaching assignment 1—lesson plan analysis task)

Here, Amelia recognized that the concept of static electricity was potentially meaningful to students but did not provide any opportunities to help students see this during the lesson. Assuming students will see the purpose as relevant to their own lives without explicitly helping them make these connections may result in missed opportunities for students to recognize how scientific ideas are personally meaningful, thus impacting their motivation to learn about science.

Criterion 3—Eliciting Students' Initial Ideas and Predictions

3a—Eliciting ideas and predictions at start of lesson. Most of the preservice teachers (RT1: 17/24; RT2: 19/24) incorrectly applied this indicator in their analysis. Typically the preservice teachers elicited students' initial ideas about the new content but not their predictions about the phenomena. This occurred despite the fact that the reflective teaching assignments explicitly reminded the preservice teachers to elicit students' predictions. For example, before engaging in the lesson activity, Claire initiated a discussion at the start of the lesson to find out students' prior ideas about clouds. She wrote, "Ask, 'What do we know about clouds?' as a question to elicit student thinking. Write responses on a piece of chart paper labeled 'What we know about clouds'" (Reflective teaching assignment 1—revised lesson plan). This was the only time students shared their ideas at the beginning of her lesson. Thus, Claire did not provide students with the opportunity to make predictions about the phenomena.

Similar to the lesson plan analysis assignments, the preservice teachers tended to possess the alternative understanding that eliciting students' initial ideas about the new content was the same as eliciting their predictions about the phenomena. Claire illustrated this alternative understanding in her application of this indicator in her analysis, writing:

> At the beginning of the lesson, does the lesson enable the teacher to elicit students' ideas about the new content and predictions about the phenomena? This is addressed in the lesson in the first science talk led by the teacher. In this talk, the teacher is recording students' initial ideas and predictions about clouds. (Claire, Reflective teaching assignment 1—lesson plan analysis task)

Like her peers, Claire did not differentiate between eliciting students' initial ideas and eliciting their predictions when she mistakenly asserted that the discussion at the beginning of the lesson would allow her to elicit both initial ideas and predictions. Failing to make a distinction between these two types of ideas may result in missed opportunities to help students learn how to make predictions about the phenomena and thus to learn about an essential aspect of inquiry.

3b—Eliciting explanations for students' ideas/predictions. The majority of the preservice teachers (RT1: 15/24; RT2: 20/24) struggled with having students provide explanations for their initial ideas about the new content and predictions about the phenomena. For example, Leah elicited students' ideas about mixtures and other related concepts but failed to elicit their explanations for their ideas, even though she applied this indicator in her analysis. She wrote:

> I will connect this lesson to the previous one (regarding atoms and molecules) by conducting a review with the students to get their minds thinking of what they already know. The investigation question for this lesson is "What is a mixture?" I will elicit students existing ideas by asking them what they know about atoms, molecules, compounds, mixtures and elements and helping them generate examples for each of these that they can refer to later in the lesson. (Leah, Reflective teaching assignment 2—revised lesson plan)

This typical example shows that many preservice teachers failed to elicit students' explanations for their initial ideas or predictions, even though more than three-fourths of them applied criterion 3 in their analyses in both reflective teaching assignments (see Table 4.6 above).

The most common alternative understanding of this indicator expressed by the preservice teachers was the idea that having students share their ideas out loud would allow them to give explanations. Leah communicated this perspective in her analysis, writing, "Students are able to explain their ideas about the new content to the entire class as we will be reviewing it as a group" (Reflective teaching assignment 2—lesson plan analysis task). Similarly, Mia also analyzed her lesson plan for opportunities for students to give explanations for their initial ideas and concluded that, "Yes, in the introduction I have the kids share out loud their answers" (Reflective teaching assignment 2—lesson plan analysis task). These responses suggest that the preservice teachers either assumed that sharing ideas in discussion was the same thing as providing explanations for ideas or that sharing ideas out loud would necessarily lead students to explain their ideas. Making either of these assumptions may result in missed opportunities for students to practice providing evidence for their ideas and for themselves as teacher to find out the origin of students' initial ideas and predictions.

Criterion 4—Providing Experiences with Phenomena

4a—Providing multiple experiences with phenomena. The majority of the preservice teachers (17/24) provided students with only one experience with the phenomenon. For example, Leah had her students observe differences in evaporation from eight containers with varying surface areas in order to help them see how surface area affects the evaporation of liquids. Similarly, Mia provided her students with only one way to learn about rivers in her lesson, writing, "We are going to use resources from the book, and on the internet, to find out different facts and characteristics about the [Mississippi] river" (Reflective teaching assignment 2—revised lesson plan). These typical examples show how most of the preservice teachers did not allow students to experience a range of phenomena, thus limiting the opportunities students had to learn about scientific ideas.

Some preservice teachers may have had to negotiate time constraints for their lesson, leading them to provide students with only one experience with phenomena. However, the preservice teachers who applied this criterion in their analysis expressed one main alternative understanding. These preservice teachers thought they provided students with multiple experiences with phenomena if they enabled their class to experience the concept through different senses. Leah illustrated this alternative understanding in her analysis, writing:

> I chose to use this [criterion] in my analysis because since so many of my students have special needs, they learn best by hearing, seeing, and experimenting with new/old information. The information will be written on the overhead, myself and the students will verbally say it, and we will test it with our experiment.

(Leah, Reflective teaching assignment 1—lesson plan analysis task)

Leah, along with many of her classmates, did not understand what counted as an experience with scientific phenomenon. Failing to understand this idea may limit the opportunities that students have to experience phenomena, and in turn, recognize the explanatory power of science ideas.

Criterion 5—Promoting Sense-Making

5a—Having students develop evidence-based explanations. Three-quarters of the preservice teachers (18/24) struggled with having students develop evidence-based explanations, even though this was explicated in the science methods course. Typically, the preservice teachers had students answer a few questions related to the science content but did not ask them to provide evidence from the lesson to support their claims. Others asked their students to simply share one thing they had learned from the lesson. For example, Carmen ended her lesson on rain in the following way, writing:

> I will discover whether or not students have taken anything from this lesson about rainfall by asking students to volunteer ideas about what they have learned. I will have my students construct explanations about what they have learned by asking students, “What have you learned today? Can you tell me one thing?” I will call on several volunteers to explain their answer to the rest of the class. (Carmen, Reflective teaching assignment 2—revised lesson plan)

This typical example shows that the preservice teachers tended to misapply this indicator, resulting in missed opportunities for students to develop evidence-based explanations.

Some preservice teachers undoubtedly failed to accurately address this indicator because they did not apply the indicator in their analysis. However, others did not address the indicator because they possessed an alternative understanding of a scientific explanation. Some preservice teachers defined an explanation as any statement that provided reasons or details for something. Leslie demonstrated this understanding in her revised lesson plan, writing:

> After watching the video clip, have students individually complete the evaluation section on the worksheet. As a class develop a list of elements every students should include in their revised scientific model. Give students 10 minutes to draw a new diagram [about how lightning forms] and write an explanation of their model. Walk around and remind students to include all of the elements on the class list and encourage them to be detailed in their diagram and explanation. Students can share with a partner when finished. (Leslie, Reflective teaching assignment 2—revised lesson plan)

Others, like Carmen above, conceptualized an explanation even more broadly, defining it as any response to a question where students have the opportunity to share their ideas. In this instance, having students 'tell,' 'describe,' or 'explain' what they think are all viewed as synonymous terms. Both of these alternative understandings of a scientific explanation have one thing in common—a de-emphasis on the role of evidence. Failing to hold students accountable for providing evidence for their ideas may result in missed opportunities for students to learn how to support their ideas and make connections between scientific concepts and their explorations.

Criterion 6—Assessing Student Learning

6a—Assessing content understanding and inquiry abilities. Two-thirds of the preservice teachers (16/24) simply listed the assessments they would use without showing how they were aligned with the learning goals. For example, Kimberly planned on using a worksheet and other assessments to gauge student learning about instincts and learned behaviors but did not articulate the connections between the assessments and the content understandings and inquiry abilities they were intended to measure. She wrote:

> I will be collecting the hand-out after it has been filled in by each of the students to give me a formal understanding of what they learned. I will also be looking for

> informal assessments throughout the lesson to see who participates and when. (Kimberly, Reflective teaching assignment 2—revised lesson plan)

Like in the lesson plan analysis assignments, these preservice teachers assumed that having an assessment would automatically allow them to measure student learning with regard to their learning goals. Making this assumption may result in missed opportunities to assess particular ideas and abilities and thus opportunities to provide feedback and revision for students.

6c—Asking students to apply their ideas to a new task. Three-quarters of the preservice teachers (18/24) did not have students apply their ideas to a new situation or task, even though the reflective teaching assignment asked them to include this in their assessment of students. However, most of them asserted in their revised lesson plans that they provided students with this opportunity. The preservice teachers tended to misapply this indicator because they possessed an alternative understanding of it. They thought students applied their ideas to a new situation or task if they used what they had learned from a reading or experiment to complete a worksheet or an assessment directly connected to the reading or experiment. Debbie illustrated this alternative understanding in the following excerpt, writing, "The properties the students observed would help them apply their newly acquired knowledge on liquids to their journal pages/grids about the bottles of liquids they had just investigated" (Reflective teaching assignment 2—revised lesson plan). Similarly, Kelly thought students had the opportunity to apply their ideas to a new task by completing a worksheet following a whole class discussion, even though the worksheet and discussion were related to the same situation. She wrote, "These assessments are very grounded in the key content, and students will have to apply the ideas of our discussion in order to complete their worksheet" (Reflective teaching assignment 2—revised lesson plan). These examples show that many preservice teachers did not give students a new task or situation in which to apply their new knowledge. This alternative understanding may result in missed opportunities for them to see if students can extend their ideas beyond the specific situation in which they were introduced.

Criterion 7—Making Science Accessible for All Students

7a—Attending to the needs of individual students. The majority of the preservice teachers (17/24) did not individualize their lesson plan at all. They did not take into consideration how the lesson might need to be adapted for specific students or groups of students, even though the reflective teaching assignment asked the preservice teachers to think about how they might attend to the needs of individual students The two preservice teachers who applied this indicator in their analysis of their lesson plan shed light on one alternative understanding underlying this indicator. Like in the lesson plan analysis assignments, these preservice teachers thought this indicator was met if the teacher had the opportunity to circulate among students during group work or independent work because this would allow them as teachers to interact with students one-on-one. For example, Lisa asserted that her lesson met this indicator, writing, "During the whole class modeling, I can circulate the room and address the needs of individuals while talking with the whole class at the same time" (Reflective teaching assignment 2—lesson plan analysis task). Similarly, Carmen thought the needs of individual students would be met if the teacher merely circulated around the classroom:

> I do not think that this particular lesson is the best example of helping a teacher to attend to the needs of individual students in my classroom. This is because the teacher does not have any time during which the students are working independently and they have the ability to walk around the classroom and have short conversations with each student. (Carmen, Reflective teaching assignment 2—lesson plan analysis task)

These preservice teachers analyzed their lesson plans to see if they had the opportunity to help students, in general. Interpreting the indicator in this way may result in missed opportunities to differentiate instruction for specific students or groups of students in their classroom.

7c—Making scientific terminology accessible to all students. Roughly half of the preservice teachers (13/24) did not meet this indicator. Some included unnecessary terminology that was not connected to their learning goals. Others provided students with a list of terms and definitions at the beginning of their lesson and then engaged them in experiences to validate these definitions, rather than having their students develop their understanding of the terms by building from their own ideas and experiences. For example, Kelly introduced her lesson by providing students with a list of liquid properties (e.g., viscosity, translucent, transparent) and their definitions and then had students investigate the different properties. Her lesson read:

> This lesson is intended to teach students the properties of liquid…The vocabulary words are discussed as a class and further shown on the property posters. Students work in groups to look closely at the liquids and decide whether or not they hold each of the properties. When they are finished, students may play liquid vocabulary card games to practice the new words. (Kelly, Reflective teaching assignment 2—revised lesson plan)

Preservice teachers, like Kelly, assumed that providing definitions at the beginning of the lesson would make scientific terms accessible to all students. This alternative understanding also emerged in the lesson plan analysis assignments. Assuming students learn science simply by memorizing definitions may result in missed opportunities for students to make sense of science for themselves and thus to develop a deep understanding of scientific concepts.

Summary

The preservice teachers demonstrated a number of strengths and weaknesses in their understanding of the reform-based criteria in their analysis of their own lesson plans. The indicators for each criterion were accurately applied in at least a few of the preservice teachers' analyses, indicating that preservice teachers are able to attend to reform goals in their analysis of poor quality lesson plans. In particular, the preservice teachers tended to demonstrate adequate understanding and application of two criteria—'attending to learning goals' and 'establishing a sense of purpose.' Despite these strengths, the preservice teachers tended to demonstrate weak or partial understanding of the rest of the reform-based criteria, misapplying their indicators and thereby illuminating alternative understandings or simply not applying the criteria in their analysis.

Conclusions

After learning about the reform-based criteria, the preservice teachers demonstrated a basic understanding of most of them when analyzing inquiry-oriented lesson plans provided by their course instructor. However, when analyzing their own lesson plans that they were responsible for teaching in their field placements, the preservice teachers demonstrated an adequate understanding of only two of the seven reform-based criteria—'attending to learning goals' and 'establishing a sense of purpose.' One of the reasons why they addressed fewer criteria in their own lesson plans is because they simply did not attend to some of the reform-based criteria in the reflective teaching assignments whereas they had to attend to the reform-based criteria in the lesson plan analysis assignments. Another reason for this difference is that the preservice teachers expressed more alternative understandings of the criteria in analyzing their own lesson plans than in the lesson plan analysis assignments. The preservice teachers may have expressed additional alternative understandings when they completed the reflective teaching assignments because their own lesson plans may have contained more inconsistencies dealing with reform recommendations than the lesson plans provided with the lesson plan analysis assignments, making the analysis a more challenging task.

Across both types of assignments, the preservice teachers consistently demonstrated an adequate understanding of how to ‘attend to learning goals’ and ‘establish a sense of purpose.’ In comparison to the other criteria, these criteria may be easier for preservice teachers to grasp and thus apply in their analysis of lesson plans. In contrast, the preservice teachers consistently struggled with ‘assessing student learning’ and ‘making science accessible to all students.’ The preservice teachers may need additional support with learning about these particular aspects of instruction and how they can attend to them in thoughtful ways in their analysis of lesson plans.

Despite these differences among the criteria, the preservice teachers demonstrated a range of alternative understandings of the individual indicators across all seven reform-based criteria. For example, some of the alternative understandings included false assumptions about lesson plans, such as assuming that learning goals would necessarily be connected to the standards and that assessments would automatically be aligned with the learning goals. The preservice teachers also had alternative understandings of scientific inquiry, including what counted as a prediction, an experience with phenomena, and an evidence-based explanation. Some of the other alternative understandings that they expressed entailed incorrectly assuming that students would recognize particular ideas without support. For example, some of the preservice teachers assumed that students would automatically see the lesson purpose as meaningful to their own lives and connected to previous lessons without making these connections explicit to them. In addition, some of the preservice teachers simply did not know how to adapt the lesson plan to address particular weaknesses, such as how to design discussion questions for facilitating student interpretation of their experiences and ideas. These dimensions capture the range of alternative understandings that the preservice teachers expressed in their analyses.

Finally, the preservice teachers had the opportunity to apply one of the criteria—'eliciting students' initial ideas and predictions'—multiple times using lesson plans highlighting different strengths and weaknesses with regard to this criterion. In their analysis of the different lesson plans, the preservice teachers expressed a range of accurate and alternative understandings that would not have been elicited if they had only analyzed one lesson plan. Having multiple opportunities to practice applying this criterion also allowed them to develop an improved understanding of its indicators over time. Additionally, when allowed to choose their own criteria for analyzing their own lesson plans, the preservice teachers were more likely to apply this criterion in their analysis, in comparison to the rest of the reform-based criteria.

The next chapter further examines the preservice teachers' pedagogical design capacity for analyzing science lesson plans, looking specifically at their analysis approaches, application of the reform-based criteria, criteria choices, and views on the importance of the criteria, when given free choice about how to analyze lessons. The chapter also explores how these dimensions changed over time, from the beginning to the end of the science methods course and into the student teaching semester.

CHAPTER 5

CHANGE OVER TIME IN PRESERVICE TEACHERS' ANALYSES

This chapter details the preservice teachers' analysis approaches, applications of the reform-based criteria, criteria choices, and views on the importance of particular criteria at the beginning of the science methods course and at the end after learning about a criterion-based approach to analysis and seven reform-based criteria for guiding their analysis of science lesson plans. It also describes the extent to which the interviewed preservice teachers continued to the use the analysis ideas from the science methods course during their student teaching semester when they planned for science instruction.

These results inform my second research question, which asks: *When not explicitly asked to apply criteria in their analyses, how do preservice elementary teachers analyze science lesson plans and how do their analyses change over time?* This chapter specifically addresses four analysis questions: *To what extent do preservice teachers use a criterion-based approach to analysis and how do their analysis approaches change over time? How well do preservice teachers address the reform-based criteria in their analyses, and how do their analyses change over time? What criteria (explicit or implicit) do preservice teachers use, and how do their criteria choices change over time? What are preservice teachers' views on the importance of their own criteria and the reform-based criteria, and how do their views change over time?* To inform these questions, I analyzed the preservice teachers' pre/posttest analyses, which asked them to critique and adapt a lesson plan that I chose as their course instructor but did not ask them to necessarily apply criteria. I also drew upon the interview data, which shed light on how the preservice teachers planned with science curriculum materials during their student teaching semester, after having taken the science methods course.

Overview of Results

At the beginning of the science methods course, the preservice teachers did not consider any pedagogical ideas a priori in their pretest analyses. Instead, they engaged in either an unsystematic or sequential approach to analysis. After learning about reform-based criteria, the majority of the preservice teachers adopted a criterion-based approach, intentionally applying specific pedagogical ideas. They also demonstrated an improved understanding of the reform-based criteria and displayed a particularly strong understanding of ‘eliciting students’ initial ideas and predictions’—the criterion that was repeated across the lesson plan analysis assignments. However, during their student teaching, none of the interviewed preservice teachers continued to explicitly apply criteria when designing curricular plans.

With regard to the substance of their analyses, the preservice teachers focused more on ideas related to reform goals than on other pedagogical ideas in their posttests, in comparison to their pretest analyses. In other words, their analyses shifted from an emphasis on the practical and affective aspects of instruction to more complex ideas related to science teaching. In the interviews the preservice teachers also expressed a shift in their views on the importance of different criteria, seeing the reform-based criteria as more important than other criteria by the end of the science methods course. The preservice teachers also engaged in a more in-depth analysis with regard to the reform-based criteria from pre to post—especially for the repeated criterion. However, by the end of their student teaching, the interviewed preservice teachers viewed other pedagogical ideas as equal in importance to the reform-based ideas and focused on only two reform-based criteria—'attending to learning goals' and 'making science accessible to all students'—in their curricular analyses.

Analysis Approaches

Analysis Approaches at the Beginning of the Science Methods Course

At the beginning of the science methods course, I asked the preservice teachers to identify the strengths and weaknesses in an inquiry-oriented science lesson plan and make adaptations to address any weaknesses. The lesson plan asked fourth and fifth grade students to build a container to keep an ice cube from melting for as long as possible, helping them learn about the concepts of melting and insulation. In critiquing and adapting the lesson plan in this very open-ended assignment, none of the preservice teachers engaged in a criterion-based approach to analysis. In other words, they did not consider more general pedagogical principles that extended beyond the specific lesson plan itself and use these principles to identify multiple strengths and/or weaknesses related to those pedagogical principles. Instead, the preservice teachers used one of two other approaches to analysis.

Some preservice teachers engaged in an unsystematic approach, identifying strengths and weaknesses by simply seeing what popped out to them as they read through the lesson plan. For example, in describing how she approached the pretest analysis, Leah said, "I didn't go in with any preconceived notions about what it should be, just because I think there's so many different ways you could approach it" (Interview 1). Similarly, Chelsea described taking an unsystematic approach to analysis, saying:

> I think for the most part, I looked at what jumped out at me. I mean I didn't go in the lesson plan thinking I'm going to look for items that deal with classroom management or engagement. I just found those things as I went along. (Chelsea, Interview 1)

The preservice teachers, who did not embrace any sort of systematicity in their analysis, tended to talk about anything that came to mind as they read through the particular lesson plan that they had received. This unsystematic approach is illustrated in an excerpt from Shelley's pretest analysis. She wrote:

> -This seems like a fun hands-on experiment for the kids to run themselves. All of the work is done by the group members, which means that each child will hopefully feel very connected to the lesson and ready to learn. Hands-on projects are always fun for the kids and provide great opportunities for learning.
> -Students must work in groups, which help them develop community learning skills and cooperation techniques—something that will come in handy their whole lives.
> -This is a topic that is very pertinent to real life. Insulating yourself or an object from the heat and vice-versa is actually a rather common occurrence.
> -This lesson takes place over the course of a few days, not just one session where a lot of information is being presented to students in a short period of time. This allows more powerful learning to take place in the classroom during the lesson. (Shelley, Pretest)

As Shelley described the strengths of the lesson, she made general comments on the hands-on activity, group work, science connections to the real world, and the timing of the lesson. This typical excerpt shows that the preservice teachers who engaged in an unsystematic approach identified strengths and weaknesses that were largely based only on the specific ideas that stood out to them in the particular lesson plan.

Other preservice teachers engaged in a sequential approach to analysis, proceeding through each section consecutively and making comments accordingly.

Teresa described how she identified strengths and weaknesses by carefully examining each step, saying:

> I just generally started going through it. I changed some of the things in the overview about what they were supposed to know or what they were bringing into it. And I slowly went through and find little places where I'd be like, "Oh, I would do this," or "I like the way that's done." So that's kind of how I did the assignment. (Teresa, Interview 1)

Amelia's analysis is a typical example of this sequential approach to analysis, showing how the sections of the lesson plan shaped what comments she decided to make. She wrote:

> - Lessons build on one another (requires use of previous experience to predict results)
> - Lessons are cooperative (students work with other group members)
> - Connected to standards
> - Teacher background information included (explains important concepts in lesson)
> - Materials and preparation steps listed for teacher
> - Prior knowledge activated through discussion of "insulation" (where heard before and what it might mean)
> - Teacher instructed to refrain from affirming or labeling ideas as inaccurate during initial discussion
> - Experiment is made as fair (all containers kept in same area of room); important for the integrity of the science and something all scientists must consider!
> - Initial exploration is connected to the idea of insulation through discussion (Amelia, Pretest)

In describing the strengths of the lesson plan, Amelia first commented on the Summary of Learning Experiences for the unit in the first two bullet points, then the Connections to the NSES Standards section, followed by the Teacher Background Information section, and Materials and Advance Preparation sections. Then within the lesson description itself, she commented on the opening discussion in the Getting Started section, the experiment in the Exploring and Discovering section, and the concluding discussion in the Processing for Meaning section. This example illustrates how that the preservice teachers who engaged in a sequential approach to analysis made comments that were based mainly on the sections that were included in the specific lesson plan that they had received.

The preservice teachers' use of an unsystematic or sequential approach to analysis shows that they tended not to think of any pedagogical ideas a priori to apply in their analysis (and thus did not *intentionally* apply criteria). Rather than explicitly bringing some of their own ideas to the analysis, they tended to rely solely on the lesson plan to determine what they would discuss in their analysis, displaying a reactive rather than a reflective disposition. These approaches to analysis resulted in the preservice teachers reacting to what was already there in the materials but not necessarily noticing what was not there. As a result, the preservice teachers' analysis ideas tended to be largely shaped by the ideas in the lesson plan rather than by both personal and curricular resources.

There was one exception to this trend. When explicitly asked whether they thought about any analysis ideas before reading the lesson plan, three of the seven interviewees mentioned that they did consider one idea a priori. In their social studies methods course, the preservice teachers had learned about the importance of attending to learning goals when planning for instruction. Nearly half of the preservice teachers (11/24) recalled learning about the analysis of learning goals and applied this idea as a criterion in their analysis, as described by Ashley:

> In our social studies methods, they really emphasized the importance of connecting learning goals to standards and everything. So, I looked at the standards and saw what they wanted to achieve and…noticed that [the lesson] did a good job of connecting the standards with the particular goals. (Ashley, Interview 1)

Here, Ashley attended to the learning goals by checking to see if they connected to the standards. Similarly, Karen analyzed the lesson's learning goals by seeing if they aligned with the lesson activities and assessments. She explained:

> I remember reading over the lesson plan at least a few times and I was trying to think about what I thought might work and what I thought wouldn't work. But I was also really focusing on stuff that we learned in social studies because that was like stuff that we've had before. And so I remember one specific thing that I did mention was to have the learning goals or objectives tied up with the activity and assessment. (Karen, Interview 1)

These excerpts show that some of the preservice teachers demonstrated a limited understanding of a criterion-based approach to analysis.

Despite this exception, the preservice teachers primarily used an unsystematic or sequential approach in their pretests, relying extensively on the lesson plan to decide what they would talk about in their analysis. Even though the preservice teachers tended not to look within themselves for ideas to guide their analysis, all of the interviewees were able to articulate a set of criteria, when asked to describe what ideas they might consider as they think about whether to use a particular science lesson plan with their students. Leah mentioned in the following excerpt several ideas that she would consider:

> I think you definitely watch to make sure that the objectives are clearly stated at the top and that the lesson plan actually meets those objectives so that there is a purpose to using it, and also so that the purpose is obvious to your students. Also, connections to the science standards, so even if the objectives are good ideas, if it doesn't connect to what they need to be learning in the school year then maybe it's not the best plan. Like maybe you can modify it so that it actually does connect. And also, how clear the directions are for the students. Explaining what they are doing, like the explanation of the terms, or even how clear is the assignment or the lesson to them? Also, the length of it, how does it realistically fit into the class? Does the class even have time depending on the part of school year you are in right now? (Leah, Interview 1)

In analyzing a lesson, Leah explained that she would examine the learning goals for clarity, their connections to the standards, and their alignment with the lesson activities.

She also mentioned that she would check for the presence and explicitness of the lesson purpose, the clarity of the directions, and the lesson length. This excerpt and others show that the preservice teachers were able to articulate several analysis criteria, many of which would serve as productive starting points for engaging in curriculum materials analysis. However, they did not think to connect these ideas to the task of analyzing curriculum materials when completing their pretest analyses.

Analysis Approaches at the End of the Science Methods Course

At the end of the semester after learning about specific criteria for analyzing lesson plans, all of the interviewees said they viewed a criterion-based approach to analysis as an authentic teaching practice. Leah exemplified this perspective, saying:

> Even a teacher who says they don't have criteria actually does even though they are not explicitly saying this is my criteria. If they've been doing it enough times, then they just subconsciously have things that they are looking for even if they don't realize it…I mean there has to be something in their minds that they're looking for. I seriously doubt they are just randomly going in and thinking this should be changed. (Leah, Interview 2)

This typical example shows that the preservice teachers viewed a criterion-based approach to analysis as relevant when planning for classroom instruction.

Additionally, over half of the preservice teachers (14/24), including four of the seven interviewees—Karen, Leah, Ashley, and Teresa, intentionally applied criteria in the posttest analysis. Teresa described this shift in her analysis approach from the beginning to the end of the semester, saying:

> The first time when I was doing it, I just looked at what stood out to me, like what's good, what's bad, what don't I like about this? Whereas [the second time] I started thinking about each of the criteria that we had…Like I wanted to make sure they are really hitting the objectives, that they have a way to assess the students, that they are giving a way to predict and record this stuff…So I had all these things in mind from class and was thinking about them and going through, looking for evidence of them. (Teresa, Interview 2)

At the end of the semester, Teresa, like some of her peers, intentionally applied particular pedagogical ideas in her posttest analysis to help her identify strengths and weaknesses in the lesson plan. Amelia illustrated this use of a criterion-based approach to analysis in the following excerpt from her posttest. She wrote:

> Sense of purpose: The lesson establishes a sense of purpose at the beginning of the lesson. The lesson instructs the teacher to tell students they will have the opportunity to learn about the concept of insulation and to investigate the melting process. Although the lesson establishes a sense of purpose at the beginning of the lesson, it is not a purpose many students would buy into. It sounds boring! The lesson would benefit from a driving or investigation question that students are asked to think about and answer. The teacher should also review what was covered in previous lessons and help students see how this lesson is related.
> Eliciting student ideas and predictions: The lesson elicits students' initial ideas about insulation and the whole-class discussion format gives the teacher a space in which to probe students answers for explanations. However, asking students about the word "insulation" only elicits the ideas from the students who know what that word means. The ideas of all students are not elicited in this discussion. The lesson also elicits students' predictions, asking students to guess how long they can keep their ice cube from completely changing states (this could be better aligned with the learning goals). The lesson does not allow for the recording of initial ideas but it does allow for the recording of predictions. (Amelia, Posttest)

Amelia, who used a sequential approach at the beginning of the semester, as described previously, adopted a criterion-based approach to analysis by the end of the semester. She applied general pedagogical ideas to her analysis and identified multiple strengths and weaknesses with regard to each idea. The above excerpt shows how she analyzed the lesson purpose for its explicitness, meaningfulness, and connection to previous lessons. She also examined the lesson plan to determine whether it elicited students' initial ideas and predictions, probed for explanations, and allowed students to record their ideas and predictions. Engaging in a criterion-based approach to analysis enabled the preservice teachers to be more systematic and thorough in their analysis of the lesson plan.

Even though the majority of the preservice teachers applied criteria in their posttest analysis, several preservice teachers (10/24), including three of the seven interviewees—Chelsea, Lisa, and Shelley, continued to use an unsystematic or sequential approach. For example, in reflecting on her analysis approach at the beginning and end of the semester, Shelley noted, "I did the same thing both times, just a quick read-through of the lesson and marking things that stuck out to me right away, things that I liked, that I didn't like. Little things that popped out right away" (Interview 2). Chelsea also noted that she did not engage in any sort of systematic analysis of the lesson plan, instead focusing only on things that jumped out to her as she read through the lesson. She explained:

> I just read through the lesson and kind of just noticed things. I just went through and things that I didn't like I would mark and things that I thought were good, I'd mark down and then I just compiled it all at the end. (Chelsea, Interview 2)

These excerpts show that some of the preservice teachers did not alter their approach to analyzing science lesson plans, even after learning about a criterion-based approach to analysis.

Why might have this been the case, especially if all of the preservice teachers stated in the post interviews that they viewed the use of criteria as authentic to classroom practice? The design of the pre/posttests may have been one of the reasons why the preservice teachers did not apply criteria in their analysis. The posttest was identical to the pretest, containing the same lesson plan and directions for the assignment. These directions, which asked the preservice teachers to identify the strengths and weaknesses in the lesson plan, were different from the other analysis assignments, which had the preservice teachers use criteria in their analysis. Therefore, the format of the posttest may have elicited the preservice teachers' experiences with completing the pretest and not their experiences with engaging in the other analysis tasks. As a result, the preservice teachers may have reverted back to their initial analysis approaches rather than recognizing that what they learned about curricular analysis during the semester was relevant. For example, when explicitly asked if she had used any criteria in completing the posttest, Chelsea remarked, "I didn't have the list [of criteria] with me. That would have been actually a really good idea to use them" (Interview 2). Here, Chelsea did not think to apply the criteria that she had learned about during the semester when she completed the posttest analysis.

Other reasons why the preservice teachers continued to use an unsystematic approach to analysis are explored in Chapter 6, which looks at the preservice teachers' beliefs about curriculum materials analysis.

Analysis Approaches During the Student Teaching Semester

Even though the majority of the preservice teachers applied a criterion-based approach to analysis at the end of the science methods course, it was uncertain whether they would continue to use this approach after the course was complete. During their student teaching semester, two of the seven interviewees, Chelsea and Shelley, did not have the opportunity to see or teach science and thus did not plan with science curriculum materials. However, all of the interviewees said they modified lessons before teaching them, whether for science or for other subject areas. For example, Karen explained that she modified lessons when planning for instruction, saying:

> The material is a giant binder of lessons and we had supplemental overheads and stuff like that. But, basically what I would do is I would take home a book and look over the lesson and change it to however it would work for me. (Karen, Interview 3)

Even though the preservice teachers tended to engage in curricular analysis during the student teaching semester, none of them said they explicitly considered criteria when planning for instruction. Leah exemplified this perspective in the following excerpt:

> I never sat down and thought, “Okay, I’m gonna look at this, this, and this.” First I would read through the lesson plan and then I would start to think about how it would play out. I really just thought about was it realistic? How could this work in my classroom? So I don’t think I went through like, “Okay, these are my criteria and this is what I’m looking for.” (Leah, Interview 3)

Even though all of the interviewees reported that they did not use criteria when analyzing lesson plans, there was one exception to this trend. Karen noted that she did consider one criterion—‘attending to learning goals’—when planning for instruction. She said:

> I would read the objectives first and from that I was looking at how were they going to accomplish these. So, I had the objectives in mind, but a lot of [the analysis] would just come to me and I’d be reading this and I’d be like, “They expect the kids to do that? What are they thinking?” (Karen, Interview 3)

Aside from this exception, none of the interviewees engaged in a criterion-based approach when immersed in their field placements, even though all of them had previously stated that they thought this approach was an authentic aspect of teaching practice and four of them had used this approach in their posttest analyses.

Summary

At the beginning of the science methods course, the preservice teachers had several ideas about analysis criteria, when explicitly asked to share ideas about how to analyze science curriculum materials. However, none of the preservice teachers connected their analysis ideas to the actual task of critiquing and adapting science lesson plans. Instead, they engaged in an unsystematic or sequential approach, relying extensively on the lesson plan itself to guide their analyses. After learning about a criterion-based approach to analysis, over half of the preservice teachers chose to use this approach when presented with an open-ended analysis task that did not explicitly ask them to use criteria. However, several preservice teachers continued to use an unsystematic or sequential approach, though this outcome may have been due, in part, to the way that the task was designed rather than an outright rejection of a criterion-based approach. Finally, during their student teaching, all of the interviewed preservice teachers reported modifying curriculum materials when planning for instruction. However, none of them said they explicitly attended to criteria when they engaged in this teaching task.

Application of the Reform-Based Criteria

I analyzed the preservice teachers' pre/posttests to determine how well they addressed each reform-based criterion and how their analyses changed over time. At the beginning of the science methods course, the preservice teachers tended to demonstrate no understanding of the reform-based criteria or only weak or partial understanding and application of them. One reason why their analysis scores may have been so low is that the preservice teachers did not have an understanding of reform-based science teaching or they did have an understanding but did not know how to apply their knowledge to the analysis task or did not see it as relevant. Another reason may have been that the pretest was not sufficiently sensitive for measuring the preservice teachers' knowledge of reform-based science teaching that they had upon entering the science methods course.

After learning about a criterion-based approach to analysis, the preservice teachers demonstrated an improved understanding and application of the reform-based criteria. Differences in scores from pre to post were statistically significant for each reform-based criterion (see Table 5.1), but, although the scores went up, they basically only improved to a weak or less weak understanding of the criteria.

Table 5.1
Mean Scores for Each Reform-Based Criterion within Pre/Posttests

Criterion	Pretest[a]			Posttest			*t*-Value[b]	Effect Size[c]
	Mean	SD	Depth[d]	Mean	SD	Depth[d]		
1-Goals	0.23	0.36	None	0.79	0.93	Weak	2.91**	0.87
2-Purpose	0.50	0.66	Weak	1.17	1.24	Weak	2.71**	0.71
3-Elicit ideas	0.58	0.72	Weak	2.17	0.87	Adequate	6.21***	2.00
4-Phenomena	0.63	0.77	Weak	1.33	1.13	Weak	2.48*	0.53
5-Sensemaking	0.25	0.44	None	0.79	0.93	Weak	2.85**	0.79
6-Assessment	0.33	0.56	None	0.71	0.75	Weak	2.84**	0.58
7-Accessibility	0.17	0.38	None	0.54	0.78	Weak	1.99*	0.64

[a] Score represents the number of indicators addressed by each preservice teacher for each criterion; maximum score = 3.0. [b] One-tailed paired samples t test, $df = 23$. [c] Effect size is calculated by dividing the difference between the mean scores by the average of the standard deviations. [d] Depth of understanding: 0.00 - 0.49 = No understanding; 0.50 - 1.49 = Weak or partial understanding; 1.50 - 2.49 = Adequate understanding; 2.50 - 3.00 = Strong understanding.
* $p<.05$, ** $p<0.01$, *** $p<0.001$

Looking across the criteria scores at the beginning of the science methods course, a repeated measured one-way ANOVA revealed that there was a significant difference in pretest scores among the seven reform-based criteria, $F(3.43, 78.96) = 2.67$, $p = .046$, though with a relatively small effect size (partial eta-squared = .10). Additionally, with Bonferroni error rate corrections, no significant comparisons were detected. These results indicate that there were negligible differences in the preservice teachers' understanding across the seven reform-based criteria at the beginning of the semester. In contrast, a repeated measures analysis showed that posttest scores were significantly different among the seven reform-based criteria at the end of the course, $F(3.83, 88.08) = 11.66$, $p = .000$, with a moderate effect size (partial eta-squared = .34). With error rate corrections, follow up comparisons revealed that criterion 3—the criterion repeated across the lesson plan analysis assignments—differed significantly from criteria 1, 5, 6, and 7 (see Table

5.1 for means). These results suggest that the preservice teachers demonstrated a stronger understanding of criterion 3 than most of the other reform-based criteria by the end of the course. Figure 5.1 displays the scores for each of the reform-based criteria in the pretest and posttest analyses.

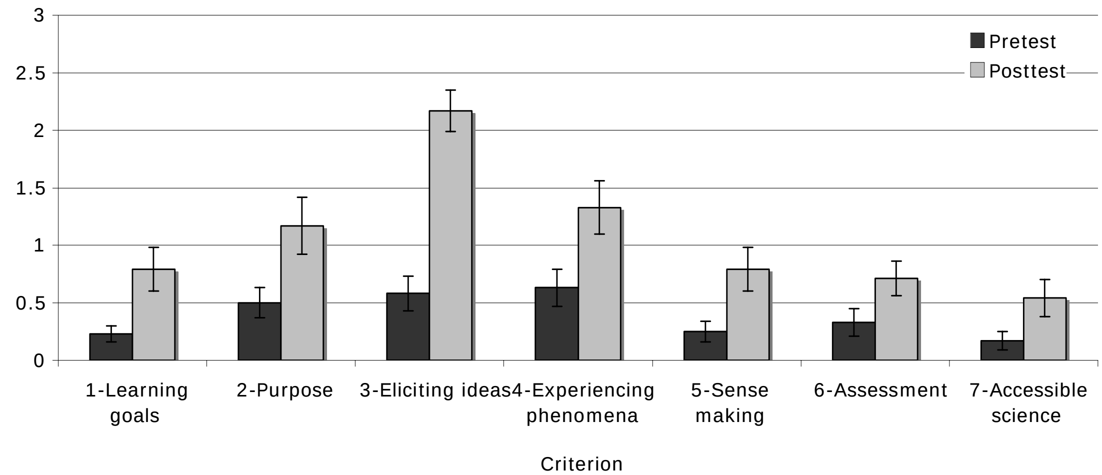

Figure 5.1. Mean scores for each reform-based criterion within pre/posttests.

Two factors influenced the pre/posttest scores. Scores depended on whether the preservice teachers applied the criteria in their analysis, that is, scores were lower if they did not apply the criteria. Scores also depended on whether the preservice teachers, who did apply the criteria, correctly applied them in their analysis. Results are reported in the next section for the first of these two factors. They describe the extent to which the preservice teachers attended to the reform-based criteria, and criterion 3, specifically, and how that changed from the beginning to the end of the science methods course. They also provide insight into the extent to which the preservice teachers addressed each of the indicators within each reform-based criterion and how that changed from pre to post.

Summary

The preservice teachers demonstrated no understanding or weak or partial understanding of the reform-based criteria in their pretest analyses. After learning about the criteria in the course, the preservice teachers demonstrated an improved understanding of the reform-based criteria. However, they still demonstrated only weak or partial understanding of all of the criteria but criterion 3, in which the preservice teachers demonstrated adequate understanding and application. This criterion was the same one that was repeated across the lesson plan analysis assignments.

Criteria Choices

Criteria Choices at Beginning and End of Science Methods Course

Before learning about specific criteria in the science methods course, the preservice teachers mentioned a range of criteria (whether explicitly or implicitly) when completing their pretest analyses, including criteria related to reform goals as well as some of their own criteria. With regard to their own criteria choices, approximately half of the preservice teachers used or mentioned each of the following seven criteria in the pretests and initial interviews: making science fun and engaging, providing students with hands-on activities, checking the lesson procedure for clarity and feasibility, managing the class, providing students with clear definitions and explanations, enabling students to develop their own investigations and understandings, and promoting cooperative learning. (This is an all-inclusive list of the most common criteria among the preservice teachers' own criteria; all other criteria were mentioned by fewer than one-fourth of the preservice teachers.) Table 5.2 includes examples of each of these seven criteria from the preservice teachers' pretests. Unlike the reform-based criteria, most of their own criteria tended to emphasize the affective and practical aspects of instruction rather than more complex ideas about teaching.

Table 5.2
Own Criteria Choices and Examples from Pretest

Criteria	Example
Fun/engaging	The task given to students appears to be very engaging: "Can our group keep our ice cube the longest??" (Lisa)
Hands-on experiences	Actual experiment: investigative, hands-on, and involved. (Maria)
Clarity/feasibility of procedures	[Clarity]: As far as setting up the experiment and going about preparing for it, I liked how thorough the steps were. It really seemed to make sure everything was thought out before springing this upon the students. (Melanie)
	[Feasibility]: After reviewing this lesson plan, I think that the suggested time is a very good estimate of how long the lesson plan will take. This is a helpful component of the lesson plan because it allows teachers to plan out enough time for the entire lesson to be completed. (Carmen)
Classroom management	Experiments should be placed somewhere out of view while ice cubes are melting so that students aren't distracted by them as you move on the other lessons. (Jackie)
Presence of explanations and definitions	Why is the definition of insulation only introduced after the lesson? Would it not be more beneficial for students to be aware of the scientific phenomena they are trying to reproduce as the engage in the activity? (Lisa)
Student-directedness	[Lesson] allows the students to investigate and build their own containers based on their thinking. (Debbie)
Cooperative learning	Students are asked to work in cooperative groups so that they gain experience about how to successfully do this. In addition they are able to collaborate on their ideas, and share the work load. (Michelle)

With regard to the frequency of their criteria choices, there was no significant difference between the number of their own criteria and the number of the reform-based criteria that the preservice teachers focused on in their pretest analyses (see Table 5.3). However, at the end of the science methods course, the preservice teachers focused on significantly more reform-based criteria than their own criteria in the posttests (see Table 5.3). Specifically, each preservice teacher attended to roughly two-thirds of the reform-based criteria (4.29/7, 62%) but far fewer of the class's own criteria (2.71/7, 39%). These results show that the preservice teachers attended to more complex ideas about teaching after learning about the reform-based criteria in the science methods course.

Table 5.3
Mean Number of Reform-Based Criteria Versus Own Criteria Applied Within Pre/Posttests

	Pretest		Posttest		*t*-Value [b]	Effect Size [c]
	Mean [a]	SD	Mean	SD		
Reform-based criteria	2.50	1.29	4.29	1.90	4.343***	1.12
Own criteria	3.33	1.43	2.71	1.27	-1.569	0.46
t-Value [b]	1.890		-3.456**			
Effect Size [c]	0.61		1.00			

[a] Mean number of criteria that each preservice teacher applied in their analysis; maximum number of reform-based criteria = 7; maximum number of own criteria = 7. [b] Two-tailed paired samples t-test, *df* = 23.
[c] Effect size is calculated by dividing the difference between the mean scores by the average of the standard deviations.
* *p*<.05, ** *p*<0.01, *** *p*<0.001

Additionally, the preservice teachers applied significantly more reform-based criteria in the posttests (4.29/7, 62%) than in the pretests (2.50/7, 36%), but there was no statistically significant difference in the number of their own criteria that they applied from pre (3.33/7, 48%) to post (2.71/7, 39%; see Table 5.3 above). These results show that the preservice teachers tended to apply a more diverse array of reform-based criteria by the end of the science methods course. Figure 5.2 displays the differences in the number of reform-based criteria and their own criteria that the preservice teachers applied in the pretest and posttest analyses.

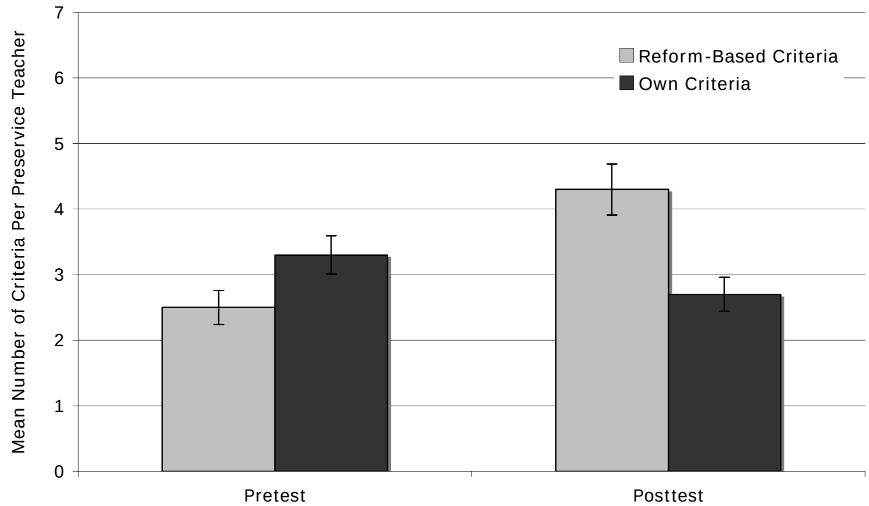

Figure 5.2. Average number of reform-based criteria versus own criteria applied by the preservice teachers within pre/posttests.

With regard to the specifics of their reform-based criteria choices, a repeated measures analysis revealed that in the pretest the preservice teachers' criteria choices did not significantly differ among the seven reform-based criteria, $F(3.87, 88.99) = 2.21$, $p = .076$, with a small effect size (partial eta-squared = .09). These results show that the preservice teachers were just as likely to use any one of the reform-based criteria in their pretest analysis (see Table 5.4 for means). However, at the end of the course, their criteria choices were significantly different among the seven reform-based criteria in the posttest, $F(4.29, 98.66) = 5.28$, $p = .001$, with a small effect size (partial eta-squared = .19). With error rate corrections, follow up comparisons revealed that criterion 3—the only criterion that was repeated across the lesson plan analysis assignments—differed significantly from all of the other reform-based criteria except criterion 4 (see Table 5.4 for means). These findings indicate that the preservice teachers tended to focus on criterion 3 more often than most of the other reform-based criteria when completing their posttests.

Table 5.4

Mean Scores for Preservice Teachers Using Each Reform-Based Criterion Within Pre/Posttests

	Pretest		Posttest	
Reform-Based Criteria	Mean [a]	SD	Mean	SD
1-Learning goals	0.38	0.50	0.54	0.51
2-Purpose	0.42	0.50	0.54	0.51
3-Elicit ideas	0.50	0.51	1.00	0.00
4-Experiencing phenomena	0.54	0.51	0.71	0.46
5-Sense-making	0.21	0.42	0.54	0.51
6-Assessment	0.29	0.46	0.54	0.51
7-Accessible science	0.17	0.38	0.42	0.50

[a] Score represents whether each preservice teacher attended to the criterion in their analysis (0 = did not attend; 1 = did attend); maximum score = 1.0.

Note. n = 24 preservice teachers

In addition to differences in their criteria choices, the preservice teachers also varied in their amount of focus between the reform-based criteria and their own criteria, as illustrated in Figure 5.3. At the beginning of the science methods course, the preservice teachers identified significantly more strengths and weaknesses related to their own criteria versus the reform-based criteria in the pretests (see Table 5.5). Specifically, they stated five claims dealing with their own criteria, on average, in comparison to only three claims dealing with the reform-based criteria. However, at the end of the course, the preservice teachers described significantly more strengths and weaknesses with regard to the reform-based criteria versus their own criteria in the posttests (see Table 5.5). Specifically, they provided, on average, nearly three times as many claims dealing with the reform-based criteria than their own criteria. These results show that the focus of the preservice teachers' analyses shifted after learning about the reform-based criteria in the course.

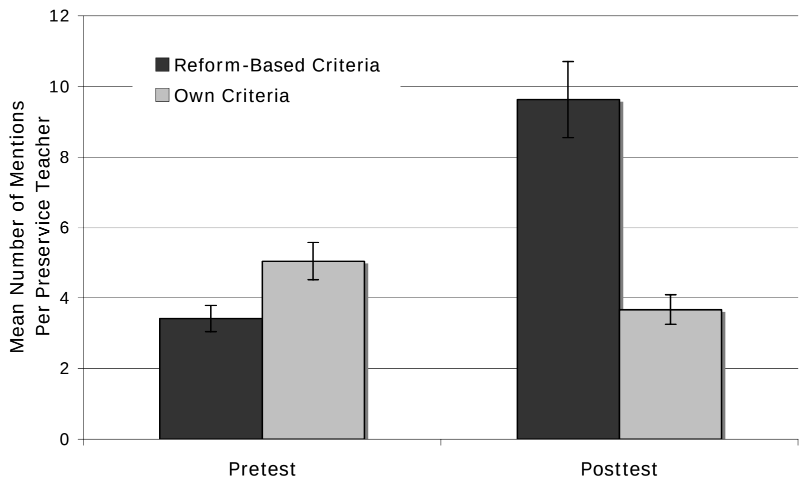

Figure 5.3. Average number of claims related to reform-based criteria versus own criteria made by the preservice teachers within the pre/posttests.

Table 5.5
Mean Number of Claims Related to Reform-Based Criteria Versus Own Criteria Within Pre/Posttests

	Pretest		Posttest		*t*-Value [b]	Effect Size [c]
	Mean [a]	SD	Mean	SD		
Reform-based criteria	3.42	1.82	9.63	5.27	6.459***	1.75
Own criteria	5.04	2.58	3.67	2.04	-1.997	0.59
t-Value [b]	2.283*		-4.738***			
Effect Size [c]	0.74		1.63			

[a] Mean number of claims related to the criteria that each preservice teacher made in their analysis. [b] Two-tailed paired samples t-test, $df = 23$. [c] Effect size is calculated by dividing the difference between the mean scores by the average of the standard deviations.
* $p<.05$, ** $p<0.01$, *** $p<0.001$

Additionally, the preservice teachers made significantly more claims related to the reform-based criteria on the posttest, in comparison to the pretest, but did not differ in the number of claims they made with regard to their own criteria (see Table 5.5 above). In fact, the preservice teachers stated, on average, nine to ten claims dealing with the reform-based criteria in the posttest—three times as many claims as in the pretest. This means that the preservice teachers attended to more of the indicators within the reform-based criteria in the posttest than in the pretest.

Specifically, most of the preservice teachers who applied the reform-based criteria in the pretest addressed only one indicator for each criterion that they mentioned. Just one or two preservice teachers, on average, attended to more than one indicator for each reform-based criterion. The most common indicators within the pretests dealt with connecting learning goals to standards (criterion 1b), connecting the lesson purpose to previous lessons (criterion 2c), eliciting students' ideas (criterion 3a), providing opportunities for students to record and analyze data (criteria 4bc), and assessing students' understanding of science ideas (criterion 6a). In the posttests, two to five preservice teachers, on average, attended to more than one indicator per criterion, which is slightly more preservice teachers than in the pretest. Additionally, most of the preservice teachers (19/24) addressed two or more indicators for criterion 3—the criterion that was repeated across the lesson plan analysis assignments. These findings show that more preservice teachers attended to more than one indicator for each reform-based criterion in the posttest, in comparison to the pretest, particularly for criterion 3. By attending to more than one indicator, the preservice teachers engaged in a deeper analysis with regard to the reform-based criteria.

The above results are illustrated below with qualitative descriptions and excerpts from the preservice teachers' pre/posttests and interview transcripts.

Illustrative examples of criteria choices at the beginning of the science methods course. In the pretest the preservice teachers stated more claims about their own criteria than about the reform-based criteria, and when they attended to the reform-based criteria, they tended to address only one indicator within each criterion. For example, Kylie identified a variety of strengths and weaknesses in her pretest. However, all but one of her claims were based on her own ideas about how to analyze science lesson plans—ideas that did not relate to aspects of reform-based teaching. Her pretest read:

> Strengths:
> The lesson has "Checkpoints" throughout which help the teacher to assess how the students are doing—if they understand what is going on and are on task.
> This seems like a fun hands-on experiment for the kids to run themselves. All of the work is done by the group members, which means that each child will hopefully feel very connected to the lesson and ready to learn. Hands-on projects are always fun for the kids and provide great opportunities for learning.
> Students must work in groups, which help them develop community learning skills and cooperation techniques—something that will come in handy their whole lives.
> Weaknesses:
> I noticed students were asked in advanced to bring in materials they thought would be good insulators. How is this possible if no talk of insulation has happened prior to the lesson? Are these the only materials that will be available for construction of the insulator? (Kylie, Pretest)

Here, Kylie tended to focus on her own criteria, including science as fun and engaging, cooperative learning, and clarity of procedures. She only applied one of the reform-based criteria in her analysis—'assessing student learning'—and specifically, only one indicator within this criterion. These findings were typical of her classmates.

Similarly, in the initial interviews, the preservice teachers described the main ideas that they addressed in their pretest analyses. These descriptions further showed that they tended to focus on their own criteria, not on ideas represented in the reform-based criteria that they would later learn about in the course. This finding is illustrated in Teresa's description of her analysis:

> I was hoping that from reading the little overview that this could be a really interactive experiment. So I was looking for interaction and I was looking for, what's the word? Management. Cause I knew that would be important if this was where kids were doing a lot that that would be an issue. Yeah, and if it was fun. I just think in this experience they could have been doing something out of the book or watching it on a video or just hearing about how ice melts. Instead they

> got to take part in an experiment where they had materials that they actually come up with on their own. (Teresa, Interview 1)

Teresa described the main ideas within her analysis—providing an interactive activity, managing students, and making science fun. She highlighted no ideas related to the reform-based criteria, focusing solely on her own criteria. By focusing minimally on the reform-based criteria, the preservice teachers limited the scope of their analyses and thus their ability to support student learning.

Within the initial interviews I further elicited the preservice teachers' analysis ideas by using different types of prompts in order to see if they also prioritized ideas related to their *own* criteria. In one question I asked the preservice teachers to share their ideas about the important characteristics of effective science teaching. In their responses the interviewees focused primarily on their own criteria—specifically, on the importance of making science fun and engaging and providing students with hands-on activities. Karen mentioned both of these ideas in her response, in addition to the importance of providing students with clear explanations. She said:

> I think getting the kids engaged is key in science. Some of the contents are really hard to understand so I notice that the kids get so much more engaged in some of the labs or hands on investigation in class as opposed to a lecture lesson. I think also it's important that the topic is well explained. (Karen, Interview 1)

Like her peers, Karen focused on ideas unrelated to the reform-based criteria when describing her ideas about effective science teaching.

Similarly, using a different question, I asked the preservice teachers to describe their ideas about criteria that they could use to analyze science lesson plans. In their responses the interviewees tended to focus on their own criteria, not the reform-based criteria, with the exception of one reform-based criterion—'attending to learning goals.' Karen illustrated this finding in the following excerpt:

> I would want to make sure I look at the unit goals and the state standards and see that objectives line up… I think also just to make sure that the kids are engaged and [the lesson] includes some process of scientific reasoning and hands-on experiences because I guess if it's just lectures, kids aren't gonna be engaged. (Karen, Interview 1)

This typical example shows that the preservice teachers again tended to focus on their own criteria, except for a focus on analyzing the lesson's learning goals. The interviewees likely mentioned this reform-based criterion because they had learned about it in their social studies method course, as Shelley explained, "Important are the standards of Michigan state, whatever they need you to teach, that's also something you need to take into account. We did a lot in the social studies methods course. We've listed them pretty much in every class" (Interview 1).

The above findings corroborate the patterns in the preservice teachers' criteria choices in the pretest analyses. Asking the preservice teachers to share their ideas about effective science teaching and their ideas about criteria elicited a narrow range of analysis ideas that did not tend to coincide with the reform-based criteria. In contrast, when I asked the preservice teachers to describe what a typical science lesson might look like during their first year of teaching, the preservice teachers had a different response. They demonstrated a wide range of ideas, many of which overlapped with the reform-based criteria. For example, Karen mentioned the importance of making the lesson purpose explicit (criterion 2a), eliciting students' initial ideas (criterion 3a), recording the class's results (criterion 4c), fostering evidence-based explanations (criterion 5a), and assessing students' understandings (criterion 6a), in addition to managing students and engaging students in hands-on activities. She said:

> I really would want to introduce a lesson, letting students know what we're going to be learning about, like what the topic is. And then asking the students, "What comes to mind when you think of this topic?" It's like taking student responses and looking at all the ideas and as you're going about this you can take this as a teacher and see how much my students know and maybe there are some misconceptions…And just starting with activity number one and explaining the rules about how we conduct ourselves in the classroom when we're doing hands-on activities or experiments. And then having students go about completing the activity. And then just coming back as a group, and discussing what people found and recording that on the board. Just something where we could have concrete evidence about what we saw and what we did. Like in science, it can be applied, like what I see and then what do I think that this means or why do I think this happened…And then as we're wrapping up the lesson, an open kind of discussion where I can maybe go around the room and ask each student a different thing they think they learned or what they learned. (Karen, Interview 1)

Karen, like her peers, mentioned a wide variety of ideas related to the reform-based criteria. These findings show that the preservice teachers did have productive ideas for analyzing science lesson plans. However, these ideas were only elicited when the preservice teachers were asked to describe their ideas about the central components of a science lesson plan. Thus, they did not recognize that they could use these ideas to guide their analysis of the lesson plan in the pretest. Instead, they tended to focus on ideas related to their own criteria, which represented a limited range of ideas about teaching.

Illustrative examples of criteria choices at the end of the science methods course. At the end of the science methods course, five of the seven interviewees mentioned that they noticed a shift in the focus of their analysis from pre to post. Four of these five interviewees also happened to be the same four individuals who adopted a criterion-based approach to analysis. These preservice teachers recognized a shift toward more central issues dealing with teaching in their posttest analysis, as illustrated in Ashley's response:

> For the initial assignment, I just wrote so many different bullets because I just was paying attention to every tiny little thing. But the second time around I just made sure to really focus on: Does the lesson help students make sense of the phenomenon or see the lesson as useful for their lives?… So I just really focused on the actual lesson and not just the technicalities of the lesson, the second time around. (Ashley, Interview 2)

Additionally, the class as a whole demonstrated a shift in focus from pre to post, placing greater emphasis on the reform-based criteria than on their own criteria and applying more reform-based criteria, overall. For example, Kylie stated more claims related to the reform-based criteria than to her own criteria in the posttest than in the pretest (see excerpt above). Specifically, she mentioned three claims related to her own criteria and only one claim related to the reform-based criterion in the pretest (see excerpt above) but seven claims about reform-based teaching in the posttest. In contrast to the pretest, she also attended to multiple indicators within each reform-based criterion in the posttest, engaging in a more in-depth analysis with regard to the reform-based criteria. She wrote:

> Strengths:
>
> This lesson does a pretty good job of eliciting student ideas. The students are asked to share and explain their ideas about insulation with the entire class. Then they also share their ideas about which container they could use to "insulate" their ice cube. However, they do not explain their reasons for why they made their choices or make any records.
>
> The checkpoints are wonderful, short assessments that help the teacher assess the students' inquiry skills and understanding of how ice melts and how that relates to insulation.
>
> In this lesson, students are able to do the work of scientists as they make observations about the ice, record their data, and share their results. They get to use the information they have learned to create a definition for "insulation."
>
> Weaknesses:
>
> Give students the opportunity to track their learning. One way to do this would be in the beginning when the teacher asks students what they think insulation is. Since the teacher is giving the students a minute or two to just think about it, they could also record their ideas in some kind of science journal and compare these original ideas to their ideas at the end of the lesson.
>
> In the beginning portion, the lesson makes it seem as if all the students will be

> sharing their ideas with the entire class. Instead, I think that have a few students share with the entire class would be fine. When the teacher looks through the science journals, s/he can get a better sense of each individual's ideas.
>
> The lesson does not require students to apply their new knowledge to a new situation. This could be amended by having the students relate this idea to how the thermos in their lunch box works, or something along those lines. (Kylie, Posttest)

In her analysis Kylie focused on eliciting students' initial ideas (criterion 3a), probing for students' explanations for their ideas (criterion 3b), having students share and record their initial ideas (criterion 3c), having students record their data (criterion 4a), engaging students in sharing their results (criterion 4c), assessing students' content understandings and inquiry skills (criterion 6a), and having students apply their newly developed ideas to a new task or situation (criterion 6c). She focused on several reform-based criteria in comparison to her own criteria and multiple indicators within each reform-based criterion, engaging in a thorough analysis with regard to some very important aspects of science teaching. This example typifies the findings across the class.

Similarly, when the interviewees described the main ideas in their posttest analyses, four of them—Karen, Leah, Ashley, and Teresa—mentioned focusing primarily on the reform-based criteria, in contrast to their pretests. Teresa's description of her posttest analysis illustrates this shift, as compared to her description of her pretest analysis (included above). She said:

> I wanted to make sure they are really hitting the objectives, that they have a way to assess the students, that they are giving a way to predict and like we can record this stuff…I think I also looked for experiences with phenomenon. I always like that and I think it's important having the experience. I think management was also one for me… I also just considered, is it enjoyable? Are kids going to get into it? Because if they enjoy it, they take more out of it. (Teresa, Interview 2)

Like in her pretest, Teresa focused on providing students with an interactive experience, managing students, and making the lesson enjoyable—criteria of her own. However, in the posttest she also focused on several reform-based criteria, including aligning the learning goals with the lesson activities (criterion 1c), eliciting students' predictions (criterion 3a), engaging students in recording data (criterion 4b), and assessing student learning (criterion 6a). Thus, she no longer focused solely on her own criteria but added ideas from the criteria learned in the course. By taking up ideas related to the reform-based criteria, the preservice teachers increased the scope of their analysis, attending to more complex ideas related to science teaching rather than focusing merely on the affective and practical aspects of instruction.

Additionally, when responding to other prompts intended to elicit their analysis ideas, the interviewees mentioned the reform-based criteria more often than their own criteria. This trend was consistent across all of the prompts, including those eliciting their ideas about the characteristics of effective science teaching, criteria they might use to analyze science curriculum materials, and the central components of a science lesson plan. This finding is in contrast to their responses to the same prompts at the beginning of the semester. For example, in the pretest, Karen focused on the importance of making science fun and engaging and providing students with hands-on activities when describing her ideas about the important characteristics of effective science teaching, as described above. However, in the posttest, Karen focused primarily on the reform-based criteria, such as eliciting students' initial ideas and predictions (criterion 3a), eliciting students' explanations for their predictions (criterion 3b), and having students make evidence-based explanations (criterion 5a). She said:

> Effective science teaching involves inquiry and I might as well ask what inquiry would be. I would say that it helps [the teacher] elicit ideas in the lesson. It helps [students] ask questions and predictions and explain reasons behind their predictions**.** And I would say that often students are involved in activities or it

> might be research, or finding ways to answer those questions that they have. And they can then draw direct conclusions from their experiments and share their ideas with all their peers. And I would also insist that effective teaching involved students having ownership of their learning, as opposed to having the teacher sit in the front and lecture, or have students read from the textbook. (Karen, Interview 2)

Like her peers, Karen mentioned a variety of ideas related to the reform-based criteria and emphasized the reform-based criteria more than her own criteria, when describing the characteristics of effective science teaching. These results corroborate findings in criteria choices in the posttest analyses.

There was one exception to these findings. The analyses of three of the seven interviewees—Lisa, Chelsea, and Shelley—did not differ in focus from pre to post. These preservice teachers were also individuals who continued to use an unsystematic or sequential approach to analysis in the posttest. Lisa recognized this lack of change in her analysis, as she described the ideas she focused on in her posttest. She said:

> One thing that bugged me was the definition of insulation at the end of the lesson, the fact that there wasn't a control container to help isolate variables, and I said the discussion at the end is only about words and no charts are created as a representation of findings. So I guess I was focused on a lot of the same things [as the pretest]. (Lisa, Interview 2)

Like a handful of the preservice teachers, Lisa, did not focus on different ideas from pre to post. Despite these anomalies, most of the class exhibited a shift in their criteria choices from the beginning to the end of the course, emphasizing the reform-based criteria more than their own criteria and a wider range of reform-based criteria, overall.

Criteria Choices During Student Teaching Semester

It was uncertain whether the preservice teachers would continue to focus on the reform-based criteria more often then their own criteria when planning for their science lessons during the student teaching semester. Therefore, I interviewed the same subset of preservice teachers at the end of their student teaching to find out what kinds of ideas they tended to consider in planning for science lessons, when they were no longer in the science methods course. Results showed that only five of the seven interviewees had the opportunity to teach science during the student teaching semester. When planning for their science lessons, all of these preservice teachers described making adaptations to their lesson plans before teaching them. In describing the kinds of modifications they made, they each mentioned only two or three main types of adaptations, representing a mix of both reform-based criteria and their own criteria. With regard to their own criteria, some of them focused on managing the class (2/5), making science fun and engaging (2/5), and providing clear explanations and definitions for students (2/5). With regard to the reform-based criteria, they focused primarily on only two of the seven criteria—'attending to learning goals' (criterion 1—3/5) and 'making science accessible to all students' (criterion 7—3/5) in their science planning. Additionally, they did not typically focus on these criteria's indicators that they had learned about in the methods course but instead tended to address to the criteria in superficial ways in their analysis. Table 5.6 includes examples of each of these criteria that the interviewees focused on during their student teaching semester. These results show that the preservice teachers focused on their own criteria just as often as the reform-based criteria when analyzing science lesson plans, and with regard to the reform-based criteria specifically, focused on only two of the seven criteria emphasized in the science methods course.

Table 5.6

Examples of Criteria Choices During Student Teaching Semester

Criteria	Example
Classroom management	I also thought about a lot of different things, like classroom management stuff because it was like, okay how am they going to record this? And how are the kids gonna get their supplies? And what am I going to need to buy? All that little management stuff. (Karen)
Fun/engaging	I also asked, "Would this lesson be engaging or would it keep the students' attention? If it was going to be boring, how can it keep the students' interest?" That's why I would change some of the examples in the unit. (Chelsea)
Presence of explanations and definitions	[Presence of definitions]: Before each lesson sometimes I would say okay well what do you think this is? But those kinds of things I just set up with my kids at the very beginning, like this is what air pressure is; this is what humidity is. Because even though I do see the value in trying to get them to guess I felt that the lessons would be more meaningful if they went in with some vocabulary so they could define what they were seeing and be able to make sense of it from the beginning. (Leah)
	[Presence of explanations]: I like to do a lot of research, making sure I really knew what I was gonna say. I didn't always write it out, which I wish I would have. Because what I discovered is it's really easy in your head to think, "Oh, yeah. I'll do this and this and this," and not really think about the language that you are going to use. And then you get up there and you're like, "How am I actually supposed to say this?" So I think one really big epiphany for me is that it's so helpful to sit down and type it out, what I'm going to say. (Lisa)
1-Learning goals	At the top of each of the lesson plans it says 'key objectives.' Those are one of the first things I looked at. I didn't know if I even agreed that it was aligned, so sometimes they were doing all this extra stuff and it's like, well that's not even the objective you want to do…And also to prepare for my unit I had looked up the GLCEs for science so those were really helpful to see like, even though this is the curriculum we are using, are these things that they even really need to know right now? So I really was just looking for the key concepts, the big ideas, the things that I knew that they would be able to take away with them. (Leah)
7-Accessible science	I modified almost every lesson for my kids because they need more time, and they need it to be as explicit as possible…I don't know if I told you this but we have 6 kids who are certified as special needs, 2 kids were just decertified, 1 kid who is diagnosed ADHD, 2 kids who should be diagnosed, and 1 boy who is a really, really slow writer and a very slow test taker. So my class is very needy. So going into these plans, I rip them apart. (Leah)

In response to other prompts intended to elicit their ideas about analysis criteria, the interviewees tended to focus on their own criteria, with the exception of reform-based criterion 1—'attending to learning goals.' For example, Karen focused entirely on her own criteria—'making science fun' and 'providing hands-on activities'—when describing her ideas about the characteristics of effective science teaching. She said:

> I think that an effective elementary teacher first has to be enthusiastic about the subject, first and foremost, because I think science is so much fun for the kids but you have to be up there and get enthusiastic about it. So, I think the first thing is just being enthusiastic. But I think you also have to be hands on, which would hopefully translate to them just really enjoying it and thinking of themselves now as scientists and wanting to learn and experiment and having fun with it. I think that's really important. (Karen, Interview 3)

Similarly, Karen's ideas about criteria she could use to analyze science lesson plans tended to emphasize the practical and affective aspects of instruction at the exclusion of focusing on more complex ideas about teaching. She focused on her own criteria, including 'classroom management,' 'feasibility of procedure,' and 'making science fun and engaging.' The reform-based criterion 'attending to learning goals' was the only exception to this trend. She explained:

> I want to look at the objectives and just make sure that at the end students will have reached the objective… Also making sure that it's workable, that it's actually going to happen in this class and that's it's not going to be absolute chaos. If there is an experiment, if I have the materials I need for it, if I need to go out and buy something, if I need to change it around because I don't have what I need. I'd probably ask myself, "Is it gonna be fun and engaging?" If not, maybe I need to add something to it or change something around. (Karen, Interview 3)

These typical examples show that the preservice teachers tended to focus primarily on their own criteria when discussing their ideas about effective science teaching and analysis criteria, just as in their initial interviews at the beginning of the methods course.

However, when asked to describe what a typical science lesson might look like during their first year of teaching, the preservice teachers were able to demonstrate a wider range of ideas that overlapped with the reform-based criteria. For example, Karen mentioned establishing the lesson purpose with an investigation question (criterion 2a), eliciting students' initial ideas and predictions (criterion 3a), probing for explanations for students' predictions (criterion 3b), and sharing results and interpreting data (criterion 4c). She said:

> A typical lesson in my class would start with a question about the topic being discussed, a question that elicits student ideas and gets them thinking about the subject. I think that question is important because it gets them into the science and it lets me know what their ideas are so I can adapt as I'm going…Then I like to go into the work, whether it's a hands on activity where students are making a prediction, getting the data, having some sort of experiment, and then drawing conclusions. I'd ask them, "What do you think we're gonna see after this experiment?" and, "Why do you think that?" The 'why' is always one of the things important to me because I want to understand how they are thinking**.** And then at the end I think it's important to have a discussion of what did we see. Analyzing the results on your own is important, but I think it's also important to analyze it as a class and come up with this whole class concept so that everybody has the same idea at the end. So that's what a typical lesson would look like in my class. (Karen, Interview 3)

These findings show that the preservice teachers did have a range of ideas dealing with the more complex aspects of teaching that they could use to analyze science lesson plans.

Summary

At the beginning of the science methods course, the preservice teachers articulated reform-based ideas that could be used to analyze science curriculum materials, when asked to share their ideas about the important features of a science lesson plan. However, the preservice teachers primarily emphasized their own criteria in their pretest analyses and in their ideas about effective science teaching and analysis criteria, thus focusing largely on the practical and affective aspects of instruction. However, at the end of the course, the preservice teachers focused on the reform-based criteria more than their own criteria as well as on a wider range of reform-based criteria. They also engaged in a more in-depth analysis with regard to the reform-based criteria; this finding was especially true for ‘eliciting students’ initial ideas and predictions’—the criterion repeated across the lesson plan analysis assignments. Finally, at the end of the student teaching semester, the interviewed preservice teachers returned entirely to a focus on the practical and affective aspects of instruction in their analysis of science lesson plans and in their ideas about effective science teaching and analysis criteria, with the exception of two of the seven reform-based criteria—‘attending to learning goals’ and ‘making science accessible to all students’—which they tended to address in only cursory and superficial ways in their analysis.

Views on the Importance of the Criteria at Beginning and End of Science Methods Course and End of Student Teaching Semester

I analyzed the preservice teachers’ interview transcripts to describe their views on the importance of the reform-based criteria versus their own criteria in order to see whether their views impacted their criteria choices. In each interview the preservice teachers categorized their own criteria and the reform-based criteria as either somewhat/not important or most/very important.

I initially looked for differences in the preservice teachers’ views on the importance of their own criteria versus the reform-based criteria at three different time points. Differences in the number of reform-based criteria versus their own criteria that the preservice teachers viewed as very important were statistically significant at the beginning and end of the course (see Table 5.7). At the beginning of the science methods course, the interviewees tended to view more of their own criteria (5.57 of 7; 80%) as very important than the reform-based criteria (4.14 of 7; 59%). However, after learning about a criterion-based approach to analysis, the reverse became true. At the end of the course, the preservice teachers tended to view more of the reform-based criteria (5.86 of 7; 84%) as very important to consider in analyzing science lesson plans than their own criteria (2.29 of 7; 33%). However, by the end of the student teaching semester, the preservice teachers tended to view the reform-based criteria (5.00 of 7; 71%) as similar in importance to their own criteria (4.57 of 7; 65%).

Table 5.7
Preservice Teachers' Views on the Importance of Reform-Based Criteria Versus Own Criteria Across Time

	Beginning of Science Methods		End of Science Methods		End of Student Teaching	
	Mean [a]	SD	Mean	SD	Mean	SD
Reform-based criteria	4.14	0.69	5.86	0.69	5.00	1.00
Own criteria	5.57	0.98	2.29	1.80	4.57	1.40
t-test [b]	2.50*		-4.75**		0.75	
Effect Size [c]	1.70		2.87		0.36	

[a] Mean number of criteria that each preservice teacher viewed as very or most important. Maximum number of reform-based criteria = 7. Maximum number of own criteria = 7. [b] Two-tailed paired samples t-test, *df* = 6. [c] Effect size is calculated by dividing the difference between the mean scores by the average of the standard deviations.
* $p<.05$, ** $p<0.01$, *** $p<0.001$

Next I examined changes in the preservice teachers' views on the importance of the own criteria with regard to time. A repeated measures analysis showed that these views varied significantly across time, $F(1.45, 8.69) = 12.15$, $p = .005$, with a large effect size (partial eta-squared = .67). Post hoc pairwise comparisons, corrected using Bonferroni adjustments, revealed a significant decrease in the mean number of criteria viewed as very important between the beginning and end of the science methods course and a significant increase between the end of the course and the student teaching semester (see Table 5.7 above for means). These results show that the preservice teachers' views on the importance of their own criteria decreased by the end of the science methods course. However, in comparison to the end of the science methods course, they viewed their own criteria as more important by the end of their student teaching semester. This perspective was similar to that held at the beginning of the science methods course.

I then examined changes in the preservice teachers' views on the importance of the reform-based criteria with regard to time. A repeated measures analysis revealed that their views varied significantly across time, $F(1.13, 6.80) = 16.62$, $p = .004$, with a large effect size (partial eta-squared = .74). Pairwise comparisons showed a significant increase in the mean number of criteria viewed as very important between the beginning and end of the science methods course and a significant decrease between the end of the science methods course and the student teaching semester (see Table 5.7 above for means). These results show that the preservice teachers viewed the reform-based criteria as more important at the end of the science methods course than at the beginning. However, their views at the end of their student teaching were similar to those held at the beginning of the course. Figure 5.4 displays the differences in the number of reform-based criteria and their own criteria that the preservice teachers viewed as most/very important across time.

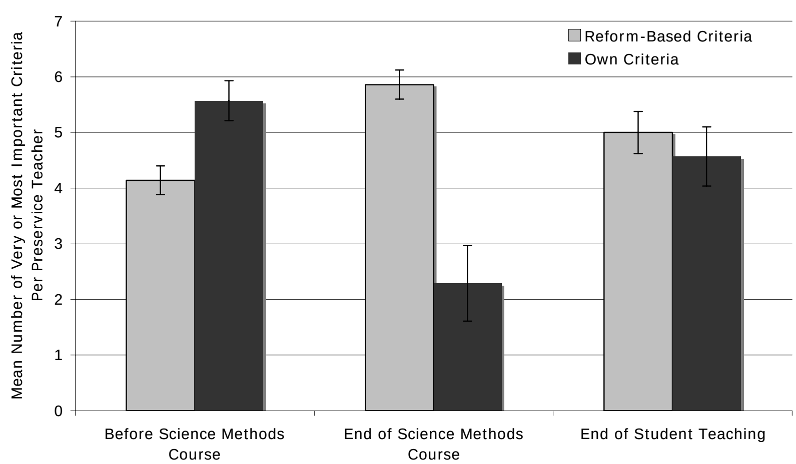

Figure 5.4. Changes across time in the number of reform-based criteria versus own criteria that the preservice teachers viewed as most/very important.

Summary

The preservice teachers viewed more of their own criteria than the reform-based criteria as very important at the beginning of the methods course, but after learning about the reform-based criteria in the course, they tended to view the reform-based criteria as more important. However, at the end of their student teaching, the preservice teachers viewed their own criteria as equally important to the reform-based criteria.

Conclusions

At the beginning of the science methods course, the preservice teachers used either an unsystematic or sequential approach when analyzing science lesson plans. However, the preservice teachers did have ideas about criteria for analyzing lesson plans, as elicited in the interviews, but they did not draw upon these ideas in their analysis perhaps because they did not see these ideas as relevant to this teaching task. With regard to the quality of their pretest analyses, few preservice teachers addressed any of the reform-based criteria, due, in part, to a misunderstanding of the criteria and to not attending to the criteria in their analysis. In fact, they tended to focus primarily on their own criteria, which emphasized the practical and affective aspects of instruction, largely because they viewed their own criteria as more important than the reform-based criteria.

After learning about reform-based criteria in the methods course, the majority of the preservice teachers adopted a criterion-based approach and accurately applied several reform-based criteria in their posttest analyses, especially the criterion that was repeated across the lesson plan analysis assignments, in particular. The preservice teachers also focused more on the reform-based criteria than their own criteria as well as on a wider range of reform-based criteria, resulting in a greater emphasis on more complex ideas about science teaching in their analyses. Paralleling these results, the preservice teachers came to view the reform-based criteria as more important than their own criteria when analyzing science curriculum materials.

During the student teaching semester, none of the interviewees explicitly attended to criteria when planning with science curriculum materials. The substance of their analyses included ideas related to both the reform-based criteria and their own criteria, paralleling findings from the preservice teachers' views on the importance of these two types of criteria. However, they only focused on two of the seven reform-based criteria—'attending to learning goals' and 'making science accessible to all students'—and their application of these criteria did not reflect an in-depth and thoughtful analysis. Additionally, in the interviews they focused primarily on their own criteria when describing their ideas about effective science teaching and analysis criteria. Thus, the preservice teachers tended to focus on the practical and affective aspects of instruction during their student teaching, with the exception of learning goals and students.

The next chapter examines the preservice teachers' beliefs about and perceptions toward curriculum materials analysis. Specifically, the chapter explores the preservice teachers' beliefs about the authenticity of this teaching practice, their comfort level with engaging in design work, and the factors that account for these beliefs and responses.

CHAPTER 6

PRESERVICE TEACHERS' BELIEFS ABOUT AND PERCEPTIONS OF CURRICULUM MATERIALS ANALYSIS

This chapter describes the preservice elementary teachers' beliefs about curriculum materials analysis as an authentic aspect of teaching practice and their views about when, how, and why teachers engage in this design task. It also focuses on how their beliefs change during the science methods course and into their student teaching semester. The chapter also describes the preservice elementary teachers' comfort level with engaging in curriculum materials analysis, the factors impacting it, and any changes in their comfort level over time.

These results shed light into my final research question, which asks: *What are preservice elementary teachers' beliefs about and perceptions of curriculum materials analysis? What reasons do they give for those beliefs and perceptions?* The first half of the chapter addresses the following analysis question: *What are preservice teachers' beliefs about curriculum materials analysis, and what accounts for these beliefs?* To inform this question, I drew upon the preservice teachers' interview transcripts as well as the class's curriculum materials use assignment, which asked the preservice teachers to observe their cooperating teacher plan for a lesson (preferably in science) and discuss with their cooperating teacher how she or he typically plans for instruction. The second half of the chapter addresses this analysis question: *What are preservice teachers'* *comfort level with engaging in the practice of analyzing curriculum materials, and what accounts for these responses?* To address this question, I analyzed the preservice teachers' interview transcripts and the class's questionnaires, which asked the preservice teachers to rank their confidence in understanding and teaching science as well as describe the amount of science courses they have taken.

Overview of Results

At the beginning of the methods course, all seven interviewees viewed curricular decision-making as an authentic aspect of teaching practice. However, they only mentioned the adaptations that teachers make during and after instruction and focused exclusively on the large-scale changes that teachers make to lessons and units. They also had limited ideas about the reasons why teachers analyze curriculum materials. By the end of the course, all of the interviewees had refined their beliefs about when and how teachers engage in design work. However, only some of the preservice teachers expanded their beliefs about why teachers engage in curricular analysis, adding the idea that teachers critique and adapt lesson plans to make them more consistent with reform-based goals. Interestingly, those whose beliefs remained unchanged were the same interviewees who did not use a criterion-based approach in their posttest analyses. These changes (or lack thereof) in beliefs persisted throughout the student teaching semester.

Two main factors shaped the interviewed preservice teachers' beliefs about curriculum materials analysis: the science methods course and their cooperating teachers. Both of these sources reinforced the same beliefs about when and how teachers plan with curriculum materials but communicated discrepant ideas about why teachers engage in curricular analysis. The science methods course promoted the idea that teachers modify lesson plans to improve their overall quality in order to provide more effective learning experiences for students, but the interviewees did not see their cooperating teachers make modifications for this reason. This inconsistency contributed to differences in belief among the preservice teachers.

At the beginning of the course, three of the seven interviewees said they felt uncomfortable designing curricular plans, largely due to their insufficient knowledge of science and science teaching and thus their limited pedagogical design capacity. Those who felt comfortable with this teaching task did not recognize the necessity of having science-specific knowledge of teaching and strong subject matter knowledge. With regard to other factors shaping their comfort level, only two of the interviewees felt like analyzing curriculum materials positioned them to question the cooperating teacher and curriculum developers—individuals whom they perceived as being of higher authority than themselves. After learning about the reform-based criteria in the science methods course, all of the interviewed preservice teachers said they felt comfortable analyzing science lesson plans, largely due to an increase in their knowledge of science teaching and pedagogical design capacity. Additionally, during their student teaching, most of them engaged in this teaching practice when planning for science instruction, and all of them said they planned on adapting their curriculum materials as new teachers. I now delve into these results further, starting with an examination of the preservice teachers' initial beliefs about curriculum materials analysis.

Beliefs About Curriculum Materials Analysis

Beliefs About Curricular Analysis at Beginning of Science Methods Course

Well-developed beliefs about curriculum materials analysis. Prior to taking the science methods course, each preservice teacher had worked with two cooperating teachers, each during a different semester of the teacher education program. However, none of the interviewees reported seeing any of their previous cooperating teachers analyze curriculum materials. Instead, two preservice teachers stated that some of their cooperating teachers created their own curriculum materials and thus did not use existing resources. Additionally, three of the preservice teachers said that they never saw their cooperating teachers even use curriculum materials, for example, as Leah explained, "I had one teacher that I felt just winged it… I never really felt like she was working from any kind of curriculum" (Interview 1). Five of the seven interviewees said that some of their cooperating teachers had published curriculum materials but appeared to use them verbatim and thus did not make adaptations. For example, Lisa described her perceptions on how previous teachers used their social studies and language arts curriculum materials, saying:

> [My cooperating teacher] actually pretty much went right from the textbooks that she got with social studies. They would read a chapter and then they would do the questions. Handouts right from the book and the kids would do them and projects right from the book. For writing, they had a writing teacher come in and she did Lucy Caulkins, and that was right out of the book. So, yeah, I can honestly say, I do not think she changed anything in any way. (Lisa, Interview 1)

Here, Lisa described her perceptions that previous classroom teachers with whom she had worked did not modify curriculum materials in anyway; others expressed similar perspectives.

Only two interviewees recognized that some of their previous cooperating teachers modified curriculum materials. These preservice teachers had the opportunity to hear their teachers describe some of the changes they had made to lessons. For example, Teresa shared:

> I haven’t seen [my cooperating teachers] critique a lesson. But, I’m sure that they have. Like they’ve talked about ways that they’ve changed it, like, “Oh, I didn’t like this section so I took it out,” or, “I decided to do it a little differently or the old way.” So I know that even though the unit says do it one way that they have changed it a little bit. (Teresa, Interview 1)

Even though most of the interviewees did not perceive that their previous cooperating teachers analyzed curriculum materials, all of them recognized that curriculum materials analysis is an authentic aspect of teaching practice. For example, Karen mentioned that she believed that most teachers, both new and experienced, were likely to engage in this design work, saying:

> I think most teachers adapt to a certain extent. There is always something in the lesson that you don’t think will work, or you think could work better. I think teachers that have been teaching for a long time have an easier time than others seeing those little things…but I think even new teachers will look at a lesson, like I looked at two lessons this time and I was like, “Well, I don’t think that would work, and I don’t think this would work.” So, I think it’s a natural part of teaching. (Karen, Interview 1)

At the beginning of the science methods course, the interviewees mentioned a variety of reasons why they thought teachers engage in curricular analysis. The main reason that all of the preservice teachers mentioned was to make written resources specific to their students’ needs. For example, Teresa stated, “Every class differs, every year differs, so I think you really have to adapt it to your students and what’s the best way they are gonna learn from the curriculum” (Interview 1). Specifically, the preservice teachers mentioned that teachers adapt lessons to take into account students’ abilities, age, behavior, and interests. For example, when discussing why teachers modify their materials, Chelsea explained that they consider their students' abilities and interests, saying, "Students change and their needs change, and their levels might change, and interests and all sorts of stuff that you should think about every year" (Interview 1).

Six of the seven preservice teachers gave a second reason for why they thought teachers engage in curricular decision-making. In addition to adapting resources for students, the interviewees also mentioned that teachers change lesson plans to match their own teaching style. Teresa shared this reason in the following excerpt:

> I think that the teacher has to personalize [his or her curriculum materials] to what they are comfortable with and to how they want to teach it. Like a lesson that my teacher does with the students I would have to do differently, adapt it, just because my personality is different. (Teresa, Interview 1)

Teresa's response gives an example showing that the preservice teachers believed teachers modify lesson plans in order to match their own teaching style.

The final reason that two interviewees mentioned at the beginning of the science methods course was that teachers adapt their written resources in order to connect them to local standards. For example, when describing why teachers engage in curriculum materials analysis, Chelsea stated, "They do [modify materials] because they need to meet standards, certain standards and certain GLCEs. And so that's why they do it and I might have to do the same thing" (Interview 1). This excerpt provides a typical example showing that the preservice teachers also recognized that teachers examine curriculum materials to see if they are aligned with state or district standards and make modifications as needed.

These findings show that the preservice teachers saw curriculum materials analysis as an authentic aspect of teaching practice because they recognized that teachers adapt resources for their own students, teaching style, and local standards. If this was the case, how did the preservice teachers reconcile their beliefs about the authenticity of curriculum materials analysis and their observations of how their previous cooperating teachers used their materials? At the beginning of the science methods course, the interviewees had a variety of reasons for why they thought their cooperating teachers did not engage in this design work. Two interviewees surmised that it might have been the first time that their cooperating teachers had used their curriculum materials, for example, as Karen stated, “This year my CT, it’s his first year of teaching this unit, his first time using this book. So he’s not changing it that much because it’s his first year of teaching it” (Interview 1). Two other preservice teachers thought that their previous cooperating teachers may have made adaptations to their curriculum materials in previous years and thus did not need to continue to modify them. Leah suggested this possibility as she reflected on her first cooperating teacher’s use of curriculum materials. She said:

> My first CT, she followed pretty closely [the district’s] curriculum. She might have modified it to suit her needs because she had been teaching for a very long time. So I got the impression she did very similar things year after year after year. So she just might already know how she has altered it and just keeps it the same. (Leah, Interview 1)

In addition to these reasons, two of the preservice teachers also thought that their cooperating teachers may not have modified their curriculum materials because they were relatively new teachers who were getting used to managing all the tasks of being a teacher. Shelley suggested this reason, saying, “If [teachers] are starting off, they’re overwhelmed with everything so they are not able to actually look through every lesson and change little things here and there” (Interview 1). Two interviewees also thought the principal might have mandated that their cooperating teachers implement the curriculum materials as-is, for example, as Shelley mentioned, “The [teachers] did Lucy Caulkins in language arts and they pretty much did it straight from the book ‘cause I think it’s how the principal wanted them to do it. So there wasn’t much adaptation there” (Interview 1). Additionally, three preservice teachers thought their cooperating teachers might not have been comfortable teaching science, leading them not to make changes to their science lesson plans. Leah suggested this reason, saying, “I think it depends on your comfort level with modifying because I mean I’m sure some teachers are more likely to modify for the subjects that they are most comfortable with, which I probably am, too” (Interview 1). One final reason suggested by one interviewee was that their cooperating teachers might have been satisfied with how their curriculum materials were written and thus did not feel like they needed to modify them, as suggested by Chelsea: “Last semester, I saw usage of curriculum materials, but the teacher seemed pretty content with how they were being used and seemed to be used effectively, so I didn’t see much changing going on” (Interview 1). These findings show that the preservice teachers saw curriculum materials analysis as authentic even when they did not see teachers modify curricular resources because they understood some of the reasons why some teachers choose not to engage in this task.

Additionally, at the beginning of the course, some of the interviewees were able to reconcile their beliefs about how teachers use curriculum materials and their actual observations of teachers by offering some reasons for why they might not have observed their previous cooperating teachers analyze curriculum materials. Two of the interviewees thought that their cooperating teachers might have engaged in curriculum design but that they did not observe this because they did not think to look for this aspect of teaching when observing their cooperating teachers' practice. Teresa explained, "I wasn't as much thinking about the planning behind [the lesson] as I was just the actual teaching. I was concentrating more on the enactment of the lesson than what's behind it" (Interview 1). Three other preservice teachers recognized that their teachers' planning might not have been visible to them. For example, as Ashley reflected on the timing of her previous cooperating teachers' planning periods, she noted:

> [Teachers] might [plan for instruction] at a time when we are not in class. Last semester we used to come in the morning, so we didn't get to see them during lunch or prep time, so they probably may do it during that time, or they may do it at home, or they may do it after school. (Ashley, Interview 1)

Ashley's response gives an example showing that some of the preservice teachers recognized that their cooperating teachers might have modified curriculum materials but at a time when they were not in their field placements.

Undeveloped beliefs about curriculum materials analysis. Even though the preservice teachers believed that curriculum materials analysis is an authentic teaching task, they articulated at the beginning of the science methods course several undeveloped ideas about when, how, and why teachers modify lesson plans. First, in discussing their views about *when* teachers engage in this design work, all of the interviewees tended to talk about how teachers critique and adapt materials *after* instruction. For example, Chelsea mentioned that teachers reflect upon their lesson enactments and make adaptations to their curriculum materials at the end of the school year, and in some cases, at the end of every week or school day. She said:

> I think for teachers who are actually in the field, they might reflect on whether or not this curriculum material was effective or not at the end of the year, I think they reflect on whether or not this worked out or that worked out. But I'm sure it depends on the teacher too, because maybe some teachers after every day or at the

> end of every week are looking at what they used that week and if it helped their students or not. (Chelsea, Interview 1)

In addition to mentioning that teachers analyze curriculum materials after instruction, six of the seven interviewees also discussed how teachers engage in this teaching task *during* lesson enactments. Lisa commented on how teachers make changes to their written resources during instruction in the following excerpt:

> Teachers adapt lesson plans in the midst of teaching: whenever Ms. C saw a teaching moment in her discussion she jumped in with insights and ideas for her students. It would have been impossible for her to plan this entire discussion. (Lisa, Curriculum materials use assignment)

These findings show that at the beginning of the science methods course the preservice teachers recognized that teachers critique and adapt curriculum materials during and after instruction. However, they rarely, if ever, considered the design work that teachers engage in when they plan for instruction, resulting in an incomplete belief about when teachers analyze written resources.

Second, in describing their beliefs about *how* teachers critique and adapt lesson plans at the beginning of the course, six of the seven interviewees tended to talk about the changes that teachers make to the structure of lessons. These large-scale changes include omitting, supplementing, or substituting entire lessons or portions of lessons (Drake & Sherin, 2006). For example, in discussing the importance of curriculum design, Leah mentioned that teachers adapt their written resources by adding to them. She said, “I don’t think that you necessarily have to follow [curriculum materials] by the book. Like bring in other things, maybe find things on-line, or find other activities for them to do just to change things up” (Interview 1). Similarly, in describing whether teachers analyze curriculum materials or not, Lisa stated that she views curriculum materials as adaptable resources, where existing resources can be omitted and new resources can be added:

> I would say that [curriculum materials] are definitely an excellent springboard and you can get a lot of ideas from them. But I do think that they have to be adapted to the group of students that you're with, the individuals that you're working with. Like bringing things into it, potentially keeping things out. (Lisa, Interview 1)

These findings show that at the beginning of the science methods course the preservice teachers recognized that as teachers critique and adapt curriculum materials, they make changes to the structure of lessons and units. However, they articulated a narrow perspective on the kinds of adaptations that teachers make. The interviewees rarely mentioned the changes that teachers make within lesson plans, such as changing the materials used, increasing student control over an activity, or making the purpose of the lesson more explicit to students (Drake & Sherin, 2006). Thus, the preservice teachers were likely to conceptualize curriculum materials analysis in terms of the large-scale changes that teachers make to lesson plans but not in terms of small-scale adaptations.

Third, at the beginning of the science methods course, all of the interviewees had a limited understanding of the reasons *why* teachers engage in curricular decision-making. They recognized that teachers analyze curriculum materials with regard to their specific students, teaching styles, and local standards, as described above. However, none of the interviewees realized that teachers also need to make adaptations to improve the quality of their materials to benefit all students. They did not recognize that many existing curricular programs fail to focus on key scientific ideas and to support students in learning about those ideas, thus needing to be adapted to compensate for their deficiencies (Hubisz, 2003; Kesidou & Roseman, 2002; Ochsendorf et al., 2004; Stern & Roseman, 2004). In the following excerpt, Ashley described her ideas about the reasons why teachers analyze their curriculum materials, focusing exclusively on making design decisions based on students and teaching styles. She said:

> A teacher knows how her students learn, how her students are, and a teacher also has the way she wants her classroom to be structured. So it's like this lesson plan may be covering an excellent unit or excellent topic that you want to cover, but just not in the way you would want to go about doing it, so I think critiquing is a way just to adapt for your students and also for your teaching style, too. (Ashley, Interview 1)

Ashley's response provides a typical example of the kinds of reasons that the preservice teachers gave for why classroom teachers critique and adapt their written resources. This finding shows that the preservice teachers were able to identify some of the reasons why teachers engage in this design work, but none of them recognized that teachers also make adaptations to better support student learning, independent of their specific students, teaching styles, and standards.

Beliefs about Curricular Analysis at End of Science Methods Course

Well-developed beliefs about curriculum materials analysis. After experiencing the science methods course, which had a strong emphasis on curriculum materials analysis, the preservice teachers refined several of their beliefs about this teaching task. By the end of the course, all of the interviewees developed the belief that teachers engage in curricular decision-making not only during and after instruction but also before they teach their lessons. For example, in reflecting on whether teachers engage in curriculum materials analysis as a part of their daily work, Teresa instantly considered the modifications that teachers make *before* instruction. She said:

> I think teachers are always changing lessons when they plan for instruction. I think that people are even doing it without realizing it. They use the curriculum but then they add something that they noticed from their class or something that they also want to emphasize. (Teresa, Interview 2)

This finding shows that by the end of the science methods course the preservice teachers refined their ideas about *when* teachers engage in curriculum materials analysis. They recognized that teachers not only make modifications to their written resources during and after the enactment of a lesson but also before instruction.

Additionally, in considering *how* teachers modify their curriculum materials, all of the interviewees described both large- and small-scale adaptations at the end of the course. For example, similar to their ideas at the beginning of the course, the preservice teachers continued to consider the changes that teachers make to the structure of lessons and units. Lisa illustrated this consideration in her reflection on how she sees herself using curriculum materials as a beginning teacher. She said:

> I think it would be exciting just to look at the [curriculum materials] and see what they have, but I would also want to be supplementing it, especially if they only give you one set. It's like one person's perspective or one organization's perspective on this. I think that there's so many more interesting things out there that you can just bring to it. (Lisa, Interview 2)

In addition to describing the additions and omissions that teachers make to lessons and units, all of the interviewees also described changes that teachers make within lesson plans themselves. For example, in discussing her views about how curriculum materials should be used, Teresa described a variety of small-scale changes that might need to be made. She said:

> Sometimes the curriculum material doesn't take into account the specific class so there will be certain things that I'll tailor it for. Like I might do management, or I might want to have a different kind of assessment than what they are using. Or, I don't think that the questions they are asking really meet the learning goals that they want, so I'll either change the learning goals or I'll change the lesson or the question around a little bit to address the learning goal. (Teresa, Interview 2)

Similarly, in describing her ideas about the role of curricular analysis in the daily work of teachers, Ashley concluded that teachers often need to make many small changes to the lesson plans that they use—with some changes being so small that they may not even be aware that they are making them. She explained:

> Every year you have a different set of students with different sets of needs and different ways of learning and it's like this lesson may not meet those needs. So I need to adjust it a little bit, not change it necessarily, but just adjust it so that we can slow the pace down if students are not grasping the concepts as quickly as the curriculum materials say that they should, or may need to have a discussion in the middle of the unit to try to make sure everything is coming together and make sure students are on the right track. So I just think that it's crucial to critique it and adapt the lesson plans for the needs of your students. And sometimes the changes are so small that when I did my assignments I would look back and there would be changes but I couldn't remember what they were. (Ashley, Interview 2)

This finding shows that by the end of the science methods course the preservice teachers modified their ideas about *how* teachers analyze their written resources. They recognized that teachers make not only large-scale changes—adaptations to the structure of lessons and units—but also small-scale changes—adaptations within the lesson plans themselves.

Finally, with regard to their beliefs about the reasons *why* teachers engage in design work, three of the seven interviewees—Karen, Leah, and Ashley—refined their beliefs by the end of the science methods course. These preservice teachers also were the same interviewees who applied a criterion-based approach in their posttest analysis (see Chapter 5). Along with recognizing that teachers modify for their specific students, teaching style, and standards, these preservice teachers added the idea that teachers also adapt curriculum materials to make them consistent with reform goals and practices. For example, Leah distinguished between the adaptations that are intended for a specific group of students and the adaptations that are intended to benefit all students, saying:

> There's some things that for any group of students you want to address. Giving them experience of predictions and explanations and learning what it means to be a scientist and those kinds of things. But then there's also other things that for your specific group you're gonna do, like reviews and extra questioning. (Leah, Interview 2)

Here, Leah recognized that teachers not only make curricular decisions based on specific students or groups of students but that they also modify their materials to improve the quality of the learning experience for all students, such as providing all students with the opportunity to make predictions and develop explanations. This typical example shows that some of the preservice teachers added to their ideas about the reasons why teachers engage in curriculum materials analysis.

Additionally, these same three preservice teachers connected the idea that teachers analyze curriculum materials to improve their overall quality to the idea that the reform-based criteria that they had learned about in class can be used to guide teachers' analysis. For example, when asked whether the reform-based criteria would benefit all teachers, Karen explained:

> So we had a class of 28 students, right? Or we all used these criteria to adapt our lessons. We all had different lessons. We were all in different grade levels. And we all used them to adapt our lesson. So I think that it's silly to assume that these criteria aren't helpful to all teachers. I think that a teacher uses the criteria to support their students' learning. So I think that all these could apply to every teacher and every student. (Karen, Interview 2)

This typical example shows how some of the preservice teachers not only recognized that teachers modify their curriculum materials to improve their quality but that teachers can use the reform-based criteria to help them think about how to improve their materials.

Undeveloped beliefs about curriculum materials analysis. Even though the preservice teachers refined their beliefs in a number of ways about when, how, and why teachers engage in curriculum materials analysis, some of the preservice teachers' beliefs remained unchanged by the end of the science methods course. Specifically, four of the seven interviewees—Lisa, Chelsea, Shelley, and Teresa—continued to have a narrow perspective on the reasons why teachers analyze their curricular resources. These preservice teachers only recognized that teachers modify their materials for their students, teaching style, and standards and thus did not see that teachers also engage in design work in order to align their materials to reform recommendations. Shelley epitomized this finding when she said:

> [Curriculum materials] are definitely a vital piece of your science teaching but not necessarily the whole thing. You can probably supplement if you find things that need to be added or that don't meet up with the benchmarks or the standards that you need to meet. Or if you just don't think your class would be able to handle this lesson or this aspect of it, it's up to you to change it to meet the needs of your classroom or your students, and I guess as well for the teacher too. You have to take that into consideration. (Shelley, Interview 2)

Here, Shelley mentioned three reasons to modify lesson plans—for standards, students, and teaching styles—but did not mention that teachers also need to make adaptations in order to improve the overall quality of their lesson plans to better support student learning. This example was typical of all four preservice teachers.

Additionally, when asked to consider whether the reform-based criteria would be beneficial for all teachers to consider, these four preservice teachers stated that the criteria would benefit all teachers but did not see the criteria as independent of specific students and teaching styles. Instead, they believed that teachers would need to adapt the criteria to fit their specific circumstances, as illustrated in Lisa's response:

> I feel like whatever type of teacher you are, you can make sure that you're paying attention to these different [reform-based criteria]. I think these are general enough where you could adapt to fit your style, to fit your students. So like, how I might promote student sensemaking and how another teacher promotes sensemaking might come about in different ways. So I just think that there are different ways. (Lisa, Interview 2)

Here, Lisa viewed the reform-based criteria as adaptable to specific students and teaching styles and thus did not recognize that some pedagogical methods for teaching science might be more effective than others. For example, she did not believe that some approaches to fostering students' sense-making might be more beneficial than others. From this perspective, having the teacher provide explanations to students would be just as beneficial as having students construct their own explanations. Overall, this excerpt shows that instead of viewing the reform-based criteria as a means to improve the quality of lesson plans, regardless of specific students and teaching styles, Lisa, like some of her peers, modified the intent of the criteria to match her prior beliefs about the reasons why teachers adapt curriculum materials.

Even more, at the end of the science methods course, one preservice teacher went so far as to say that there was not even one criterion that is important for all teachers to attend to in their analysis. Teresa maintained this perspective, even when asked about the importance of specific reform-based criteria, such as making sure learning goals are aligned with the lesson and helping students see the lesson purpose as connected to their lives. She said, "I don't think there's one thing that all lessons would really need to have that teachers have to do, like an adaptation that they would have to do. I think that it really depends on the classroom" (Teresa, Interview 2). Taken together, these findings show that by the end of the science methods course, some of the preservice teachers continued to think that teachers only modify lesson plans for their students, teaching style, and standards, and simply integrated what they learned about reform-based criteria into their initial beliefs about why teachers engage in curricular decision-making.

Interestingly, three of the four interviewees—Lisa, Chelsea, and Shelley—who had a narrow perspective on why teachers analyze curriculum materials did not adopt a criterion-based approach to analysis by the end of the course (see Chapter 5). Rather than using criteria to guide their posttest analysis, they engaged in an unsystematic approach, letting the lesson plan guide their ideas about what to discuss in their analysis. Lisa shed some light on why she engaged in this approach, saying:

> If I was doing [the analysis] for a class, I'm just gonna read [the lesson plan] through, see what's there, and what pops out at me. If I'm in an actual classroom setting and have worked with the kids for awhile, I think I might have some ideas of what I want to get out of [the lesson] before even looking at it. So I think that if I'm actually in the classroom and been with them for awhile, I'd know what types of different learners I have in my class, what they're interested in, where they're struggling, where I want them to make progress. And so I think with my lessons I'd go into them with more specific goals about what I want them to have in terms of content and skills. So I'd be thinking about those before I read the lesson plan. (Lisa, Interview 2)

Here, Lisa did not view the reform-based criteria as relevant for helping her analyze lesson plans but instead believed that the criteria that teachers use must always be specific to their students. Thus, because she was not asked to consider a specific classroom when she completed the posttest analysis, Lisa did not view the reform-based criteria as relevant. The other two interviewees—Chelsea and Shelley—held a similar perspective. This finding shows that some of the preservice teachers did not view the reform-based criteria as relevant in and of themselves but instead believed that the criteria were only useful within a specific context.

Beliefs about Curricular Analysis at End of Student Teaching Semester

After the completion of the science methods course, it was uncertain whether the changes in preservice teachers' beliefs about curriculum materials analysis would persist as they completed their student teaching semester. Therefore, I conducted a final interview with the preservice teachers at the end of their student teaching, three months after taking the science methods course, to see in what ways their beliefs had changed or remained the same. All of the interviewees continued to recognize that teachers engage in curriculum design not only during and after instruction but also before a lesson enactment. Additionally, they continued to recognize that curricular analysis entails making both large- and small-scale changes to lesson plans. For example, in discussing how she prepared for the science unit that she taught, Leah mentioned that she critiqued and adapted her materials when she planned for instruction and made additions and omissions to the unit as well as changes within the lesson plans themselves. She explained:

> The actual unit was 20 lessons. I used 14 of theirs and one of my own. It's a good curriculum, but it's pretty redundant…so I definitely cut out a lot of it. I also modified almost every lesson for my kids because they need more time, and they need it to be as explicit as possible…[For example,] I would write out what notes I would want for them. This curriculum doesn't have them taking any notes, so I just set up with my kids at the very beginning, like this is what air pressure is; this is what humidity is. I felt that the lessons would be more meaningful if they went in with some vocabulary so they could define what they were seeing and be able to make sense of it from the beginning. (Leah, Interview 3)

This excerpt shows that Leah continued to recognize that teachers engage in curriculum materials analysis when they plan for instruction and make both large- and small-scale changes to their materials. This finding was typical of all the interviewees.

With regard to *why* teachers engage in the process of curriculum design, the same three preservice teachers—Karen, Leah, and Ashley—continued to think by the end of the student teaching semester that teachers modify lesson plans to make them consistent with reform goals and practices, in addition to students' needs, teaching style, and standards. Karen mentioned this reason when she reflected on how she sees herself using her curriculum materials when she becomes a teacher. She said:

> I think the first thing I would do is, ideally, I'll have my job so I can look through it in August and be like, "Okay, what makes sense about this? What doesn't make sense?" That's even before I meet my students, like what do I like about it, and

> what don't I like? So I think in terms of what I might add to it, what will I take away, how I might change things, even before meeting them. (Karen, Interview 3)

Here, Karen distinguished between the changes she plans on making to improve the quality of her curriculum materials and the changes she plans on making for her specific students. Similarly, when asked if there are any criteria that are beneficial for all teachers to consider, Ashley responded:

> I believe that it's important for all teachers to pay attention to some criteria. Like attending to learning goals or assessing student learning, the curriculum material may not cover these well. So you might definitely want to go through and just look at the lesson and say to yourself, "Okay, what's a better way for me to assess these students and make sure that I'm attending to these learning goals?" So I think that criteria are definitely something that all teachers should do. (Ashley, Interview 3)

This excerpt shows that Ashley recognized that teachers need to attend to the reform-based criteria in order to make adaptations, independent of their specific context, that compensate for weaknesses in the materials with regard to promoting student learning. This perspective was typical of all three interviewees.

In contrast, the same four interviewees—Lisa, Chelsea, Shelley, and Teresa—who did not expand their beliefs during the science methods course about why teachers engage in curriculum design continued to believe by the end of the student teaching semester that teachers only modify for their students, teaching style, and standards. For example, when asked how she plans on using curriculum materials during her first of teaching, Teresa commented:

> I will use [the curriculum materials] the same way that I did in student teaching. They are a great place to start and get ideas. However, I always critique and adapt my materials for one reason or another. I will find a way to incorporate the materials with my natural teaching style and to meet the needs of my students. (Teresa, Interview 3)

In addition to designing instruction for their own students and teaching style, these preservice teachers also mentioned that teachers make modifications based on their standards, as exemplified in Chelsea's response: "Also you need to look at the standards because you do need to meet those goals. And you need to make sure your students are hitting those benchmarks" (Interview 3).

Additionally, these preservice teachers continued to believe by the end of the student teaching semester that the reform-based criteria learned in class were only useful if teachers adapted them for their own specific context, particularly for their students. For example, when asked whether there are any criteria that are important for all teachers to consider, Chelsea said:

> [I] think that adaptations will be different for each of their groups of students, just because within your classroom in any given year you have so many different learning styles and ability levels. So, what works one year might not work for the next, even in terms of assessment or hands on activities. You should be able to feel that out and know that after awhile. Also the criteria that you choose might look different depending on your students. I mean you might not be thinking too much about eliciting student predictions at the beginning of a lesson with one group but for the next group, you might. (Chelsea, Interview 3)

Here, Chelsea mentioned that the adaptations that teachers make are always specific to their students and that there is not one criterion that is important for all teachers to consider in their design of curricular plans.

Factors Impacting Preservice Teachers' Beliefs about Curriculum Materials Analysis

Two prominent factors mediated the changes or lack of changes in the preservice teachers' beliefs about curriculum materials analysis. First, the science methods course itself served as a powerful intervention in shaping their beliefs. The preservice teachers had a number of different opportunities to interact with curriculum materials in the course. They learned about several criteria representing reform-based ideas about teaching and practiced applying the criteria in their analysis of inquiry-oriented science lesson plans. They also applied criteria in their analysis of their own lesson plans that they were responsible for teaching in their field placements. These assignments provided the preservice teachers with the opportunity to learn that teachers modify curriculum materials during planning and make a variety of changes within lesson plans to improve how the subject matter is taught, as described in Chapters 4 and 5.

All of the interviewees pointed to these assignments as a factor influencing changes in their beliefs about curriculum materials analysis. For example, as noted earlier, Shelley explained that the lesson plan analysis assignments enabled her to recognize that it is important to critique and adapt curriculum materials, even if it means just making small changes to lesson plans. She said, “I think those [lesson plan analysis assignments] have really helped a lot, to kind of show you that, yeah, there are some great lessons out there but there are things that maybe need to be tweaked in them” (Interview 2). Similarly, Teresa mentioned that the reflective teaching assignments helped her recognize that she needed to consider some ideas before teaching a lesson to her students. She explained, “Your reflective teaching assignments were probably most helpful. They forced me to look at curriculum materials and then I was like, ‘Okay now that I see these, what am I gonna do in my own classroom to make this work?’” (Interview 2). These excerpts exemplify the idea that the variety of experiences provided in the science methods course impacted the preservice teachers’ beliefs about when, how, and why teachers analyze curriculum materials.

Second, six of the seven interviewees mentioned that observations of and conversations with their cooperating teacher shaped their beliefs about curriculum design.

As part of the science methods course, the preservice teachers completed an assignment where they discussed with their cooperating teacher how she or he planned for a particular lesson and how she or he plans for instruction, more generally. This assignment enabled the preservice teachers to see that practicing teachers modify materials when they plan for instruction, not just during and after a lesson. Teresa described this idea in her assignment, saying, "I got to see some of the behind the scenes work that goes on in teaching. I always get to see the actual lesson and its execution but not the planning or reasoning behind it until this semester" (Curriculum materials use assignment). Similarly, Shelley gained insight from this assignment about when teachers modify lesson plans, writing, "When I asked my [cooperating teacher] if she changes curriculum materials around when she is planning for lessons, she replied, 'Always.' She said there is rarely a lesson when she ISN'T making changes here and there" (Curriculum materials use assignment). This assignment also enabled the interviewees to see how teachers modify materials—that they make not only large-scale changes but also small-scale modifications. For example, Ashley described a small-scale change that her cooperating teacher made within her lesson plan, writing:

> When she was preparing for the lesson, she made a change based on the needs of her students. She said the lesson started to have the students work on their journal pages by themselves, but she decided to go through the first two questions as a whole class and the third one she was going to have them try by themselves. (Ashley, Curriculum materials use assignment)

In addition to the curriculum materials use assignment, some of the interviewees described informal opportunities they had to gain glimpses into their cooperating teacher's curricular practices, as illustrated in a comment by Chelsea: "I wouldn't see her directly plan for the instruction, but sometimes she would talk a little bit about it right before she taught the lesson, 'cause the kids had recess, before they came in and had science" (Interview 2). These interactions with their cooperating teacher enabled the preservice teachers to further learn that teachers make large- and small-scale adaptations when planning for instruction. These findings show that the interviewees' interactions with their cooperating teacher reinforced the beliefs promoted in the science methods course dealing with *when* and *how* teachers analyze materials.

In contrast, the reasons communicated by the preservice teachers' cooperating teachers about *why* teachers engage in design work differed from the reasons promoted in the science methods course. None of the interviewees mentioned that they saw their cooperating teachers modify materials in order to make them more consistent with reform goals—an important reason emphasized in the course. Instead, they learned that their cooperating teachers engaged in curriculum design for a variety of other reasons. For example, all of the interviewees mentioned that their cooperating teachers analyzed curriculum materials for their students, as exemplified in Leah's response: "I don't think that [my cooperating teacher] does any lesson without adapting it. She said it's the lowest group she's ever had, so I think because of that, pretty much every subject is modified extensively" (Interview 2). In addition to students, three of the interviewees also mentioned that their cooperating teachers analyzed their curriculum materials with regard to the standards. For example, Lisa observed her cooperating teacher compare the Michigan Grade Level Content Expectations (GLCEs) to the content in her curriculum materials. She explained, "The big push is looking at the GLCEs…I actually got to see my teacher sitting down and looking at the curriculum, making changes for next year and seeing her work through, 'Well, how can we fit all this in?'" (Interview 3).

Similarly, in the curriculum materials use assignment, all of the interviewees mentioned that their cooperating teachers modify their written resources but did not mention that their cooperating teachers modify to improve how the subject matter is taught. Instead, they mentioned that their cooperating teachers base the design of their curricular plans on other considerations, including their students (5/7), resource and time availability (3/7), teaching style (4/7), standards (2/7), and the extent to which their materials make science fun and engaging (4/7). For example, Shelley learned that her cooperating teacher considered her students and teaching style during curricular planning: "[My cooperating teacher] said there is rarely a lesson when she ISN'T making changes here and there to better suit her students…She also noted that some of the lessons don't suit her teaching style which is another reason why she makes alterations" (Curriculum materials use assignment). Teresa's cooperating teacher mentioned other reasons—standards and availability of resources and time—for why she engages in curriculum materials analysis. Teresa explained:

> My teacher often makes changes to lessons before teaching them for many different reasons. She may change a lesson before teaching it because the district requirements have changed. She may also make changes to a lesson because different materials or manipulatives are available. Another reason that she may change a lesson is because of a timeslot that she has to fit her lesson into. (Teresa, Curriculum materials use assignment)

These excerpts highlight the idea that the preservice teachers' experiences with their cooperating teachers communicated a limited set of reasons for *why* teachers analyze curriculum materials.

Summary

At the beginning of the methods course, the interviewees viewed curriculum materials analysis as an authentic aspect of teaching practice but expressed a variety of undeveloped beliefs about when, how, and why teachers engage in design work. By the end of the course, the interviewees refined their beliefs, recognizing that teachers modify materials before, in addition to during and after, instruction and make both large- and small-scale changes. However, only three of the seven interviewees expanded their beliefs about *why* teachers engage in curricular analysis to include the idea that teachers adapt materials to align them with reform goals and practices. The other interviewees did not adopt this belief; of these individuals, three of them also happened to be the same interviewees who did not use criteria in their posttest analyses. The interviewees' beliefs did not continue to change during their student teaching semester.

Two main factors mediated changes in the preservice teachers' beliefs—the science methods course and field placements. These experiences communicated consistent ideas about *when* and *how* teachers analyze curriculum materials, positively influencing changes in preservice teachers' beliefs. However, they conveyed discrepant ideas about *why* teachers engage in design work. The course emphasized the importance of making modifications to improve how the subject matter is taught, but none of the interviewees' cooperating teachers said they modified materials for this reason. As a result, some interviewees, whose cooperating teachers moderated the impact of the course, disregarded the belief that teachers adapt lesson plans in order to make them consistent with reform goals and practices.

Comfort Level with Analyzing Curriculum Materials

Comfort Level with Curricular Analysis at Beginning of Science Methods Course

At the beginning of the science methods course, three of the seven interviewees stated that they felt comfortable analyzing science lesson plans, rating their comfort level a 4 on a scale of 1-5, with 1 being very uncomfortable and 5 being very comfortable with the design work of teachers. For example, Ashley stated, “I guess I’m pretty comfortable, like probably a 4” (Interview 1). In contrast, the other four preservice teachers said they generally felt uncomfortable engaging in this analysis task, rating their comfort level at a 2. For example, Karen explained, “I’m not comfortable with it, but I’m not like, ‘Oh my gosh! I can’t do it.’ So I feel like maybe 1.5 to 2” (Interview 1). Despite this range in comfort levels at the beginning of the course, most of the interviewees cited at least one factor negatively impacting their comfort level with analyzing science curriculum materials (for a summary, see Table 6.1). I explore these factors below.

Table 6.1
Preservice Teachers’ Comfort Level at Beginning of Science Methods Course and Factors Negatively Impacting Their Response

Participant	Comfort Level	Factors Impacting Comfort Level		
		Personal Resources Impacting Pedagogical Design Capacity	Curriculum Developers	Cooperating Teacher
Leah	Low	X		
Karen	Low	X		
Shelley	Low	X		
Chelsea	Low	X		
Lisa	High			X
Ashley	High		X	
Teresa	High			

Pedagogical design capacity. At the beginning of the science methods course, four of the seven interviewees said they did not feel comfortable critiquing and adapting science curriculum materials because they did not have the knowledge and skills for engaging in this task. In particular, these preservice teachers cited two aspects of their pedagogical design capacity impacting their comfort level. First, the preservice teachers’ science subject matter knowledge influenced their comfort level. Three-fourths of the class (18/24) took mainly primary science courses (i.e., biology, chemistry, physics) throughout their education and took two or fewer of these courses at the college level. Unsurprisingly, roughly three-fourths of the preservice teachers (17/24) reported having little confidence in their science subject matter knowledge. When interviewing the preservice teachers, four of the seven interviewees pointed to this gap in their science knowledge as negatively impacting their ability to analyze curriculum materials. For example, Shelley described her limited knowledge of science and how it impacted her ability to engage in analysis, saying, “I just haven’t retained as much as I should have throughout the years, so it also contributes to my lack of confidence in critiquing and finding the strengths and weaknesses because I’m not exactly sure of the concepts being explained” (Interview 1).

Second, the preservice teachers’ pedagogical content knowledge for science teaching shaped their comfort level with designing curricular plans. Nearly three-fourths of the preservice teachers (17/24) stated that they did not feel confident in teaching science at the beginning of the course. Even more, three of the seven interviewees mentioned that their limited pedagogical content knowledge for science teaching impacted their ability to identify strengths and weaknesses and make adaptations to lesson plans, for example, as Karen explained:

> Even though I’ve had some experience, I don’t think I’ve had a lot of experience. Like, doing that [pretest analysis], it was hard on me. I was like, “Is this really a strength?” or, “What makes it a strength?” or, “What makes it a weakness?” So it was hard for me to think about that ‘cause I haven’t had a bunch of experience with teaching science. So I think I definitely have a lot of room for improvement. (Karen, Interview 1)

Here, Karen stated that her limited ideas about how to teach science impacted her pedagogical design capacity for analyzing science curriculum materials. This example was typical of all three interviewees. These findings show that some of the preservice teachers recognized gaps in their knowledge of science and science teaching and that these gaps impacted their pedagogical design capacity and thus their comfort level with analyzing science curriculum materials

In contrast, three interviewees felt that they had the knowledge and skills needed to engage in curricular analysis at the beginning of the course. Specifically, when asked about the depth of their science subject matter knowledge, all three of these preservice teachers admitted that they did not have a very strong knowledge base. However, they did not feel that this impacted their ability to analyze science curriculum materials. For example, when asked whether she felt she had sufficient science knowledge for engaging in this teaching task, Ashley believed that she did because she had a rudimentary understanding of science concepts. She explained:

> I guess there probably are some things I've learned and I may not remember as well as I would like to remember. But, on an elementary level, I think I know a good amount of science. Now I guess if we're talking about high school chemistry and physics and stuff like that, I probably wouldn't be as confident. But, when we're just talking about things you learn at elementary school, I think I would be comfortable with that type of content. (Ashley, Interview 1)

Here, Ashley believed that having an elementary school student's level of understanding of science was sufficient for engaging in the design work of teachers. This response was typical of all three of these interviewees. This finding shows that these preservice teachers did not fully appreciate the need for strong subject matter knowledge in order to effectively critique and adapt science curriculum materials.

With regard to their pedagogical content knowledge for science teaching, these same three interviewees believed that they had sufficient knowledge for science teaching or did not recognize that this knowledge was needed for analyzing science lesson plans.

For example, one of these preservice teachers stated that she had developed her knowledge of teaching during her first year in the teacher education program and felt that this knowledge was sufficient for engaging in design work. This perspective is exemplified in Lisa's response, when she said:

> Hopefully anyone in my cohort or anyone in the School of Ed should feel pretty comfortable finding strengths and weaknesses 'cause it's kind of something we unconsciously do in our field placements every day. You know, picking up on things that are good, things that aren't so good. (Lisa, Interview 1)

Lisa believed that analyzing science curriculum materials requires the application of only general knowledge of teaching and thus did not recognize that knowledge specific to science teaching is also needed in order to successfully plan for science instruction, specifically.

Another interviewee stated that she had developed an understanding of how to teach science from her previous experiences as a science learner, which positively impacted her comfort level with analyzing science curricula. Ashley explained her perspective, saying:

> I would be comfortable [analyzing science lesson plans] just because I would think about my experiences and what I found enjoyable and see if when I'm critiquing lessons if I think that that would be something that students would enjoy as well. I would critique to see how much of the textbook is used as opposed to how much the teacher is having the kids do things on their own. And if there's any type of discussion and things like that. So I would compare my experiences as a student with what's put forth on the lesson plan to try and see if the lesson would be effective. (Ashley, Interview 1)

Here, Ashley thought she had developed sufficient pedagogical content knowledge for science teaching from her experiences as a science student to enable her to engage in curriculum materials analysis. She did not recognize that her knowledge of science teaching might have been limited in some ways or that her science learning experiences might not have even been representative of effective science teaching.

The third interviewee stated that she had the knowledge and skills for analyzing science lesson plans because she believed that curricular planning is based on individual preference and thus cannot be taught. Teresa shared this idea in the following excerpt:

> I don't think [analyzing curriculum materials] is something you just learn from taking a class. It's always very hypothetical and you have to use your experience and what you learned to adapt it for your own teaching style 'cause it's personal if you're looking for strengths and weaknesses. People have really different opinions. I might think something is a strength whereas someone else may think it is a weakness. So I'd say it's personal. (Teresa, Interview 1)

This excerpt shows that Teresa did not recognize that some approaches to teaching science are more effective than others in promoting student learning, even though teaching does entail individuality. Thus, she did not recognize that developing her pedagogical content knowledge for science teaching was important for making informed curricular decisions and that curricular analysis is not entirely based upon personal preference and choice.

Authority of curriculum developers. At the beginning of the science methods course, only one interviewee said she felt uncomfortable engaging in curricular analysis because she felt like she was questioning the knowledge and authority of the curriculum developers. Ashley shared this perspective in the following passage:

> When I read a lesson plan I see typed and it's probably usually by a teacher or a board of educators or something, I'm just thinking, "Wow! They have all this experience. They probably have gone and gotten their bachelors, masters, maybe even Ph.D.s, and who am I as an undergraduate student, who has some experience but is not anywhere near their level of expertise, how can I really find mistakes of someone at such a higher level, who has had so much more experience than I have?" (Ashley, Interview 1)

Here, Ashley stated that she believed it is unlikely for new teachers to be able to find any weaknesses in curriculum materials since the writers of those materials have a lot more experience and education than them.

The other six interviewees did not feel like they were questioning the knowledge and authority of the curriculum developers when asked to engage in curricular analysis. These preservice teachers gave one main reason for this perspective. They stated that curriculum developers tend to design materials for a wide audience and general context and that teachers thus need to tailor materials to their own specific circumstances, including their own students, teaching styles, and standards. Karen illustrated this perspective in the following excerpt:

> You need to critique them to help you present the lessons in a manner that would be beneficial to the students, [The curriculum developers] try to make them as uniform as possible but every classroom isn't uniform. There's different types of students, different types of learners, and as a teacher gets to know her class more and more, she'll know that some groups of students may not benefit from the way the lesson is set up…so you have to take your students into consideration often when critiquing a lesson. (Karen, Interview 1)

This excerpt provides a typical example of the main reason why the knowledge and authority of the curriculum developers did not impact the preservice teachers' comfort level with analyzing curriculum materials. The preservice teachers understood that teachers often need to make local adaptations to their materials in order to take into consideration specific learners and circumstances. However, this finding also shows that the preservice teachers did not recognize that many published materials also do not effectively support student learning (Kesidou & Roseman, 2002) and thus need to be adapted to improve how the subject matter is taught.

Authority of cooperating teacher. At the beginning of the science methods course, only one interviewee stated that the knowledge and authority of her cooperating teacher impacted her comfort level with analyzing curriculum materials. Lisa explained that she felt this way because her cooperating teacher used lesson plans that she had designed or modified herself. Lisa provided a description of her cooperating teacher's science resources, saying, "[My cooperating teacher] conglomerated from everything else…I know some is the textbook, it's also her own research, some is just things that she wrote up herself" (Interview 1). When asked to describe her comfort level with analyzing her cooperating teacher's lesson plans, Lisa explained:

> I wouldn't be uncomfortable critiquing it and giving it to you [my course instructor], saying this is my critique of my [cooperating teacher]'s lesson if she didn't see it. But the fact that I would be up there teaching it and changing things around, I don't know. I think that I would just feel funny, knowing what she had written down and me doing something different. Or I feel like she would be critiquing me like, "Who is she?" I just wouldn't want to offend her. (Lisa, Interview 1)

Here, Lisa explained that she would not feel comfortable modifying her cooperating teacher's curriculum materials because her teacher had designed or modified the materials herself.

The other preservice teachers besides Lisa provided a variety of reasons why the knowledge and authority of their cooperating teacher did not influence their comfort level with designing curricular plans or positive influenced it. First, four interviewees mentioned that their cooperating teacher used a published curricular program and that they thus would not be using materials that their cooperating teacher had developed. Karen explained, "It's not going to bother me [to modify the materials] because it's straight from the scripted science curriculum" (Interview 1). Second, two preservice teachers explained that their previous cooperating teachers engaged in curriculum materials analysis and thus concluded that it would be permissible, if not expected, for them to do the same. Finally, two interviewees stated that their teaching style and needs might differ from their cooperating teacher's and thus would need to adapt the lesson plans to accommodate their own style and needs. Teresa explained this perspective, saying:

> I think that the teacher has to personalize [curriculum materials] to what they are comfortable with and to how they want to teach it. Like a lesson that my teacher does with the students, I would have to do differently just because my personality is different. (Teresa, Interview 1)

This excerpt provides an example that some preservice teachers believed that differences in teaching style helped them justify modifying their cooperating teacher's curriculum materials. This reason, along with the others, enabled most of the preservice teachers to feel comfortable analyzing lesson plans from their cooperating teacher. However, despite this list of reasons, it is interesting to note that none of these preservice teachers recognized that many published curriculum materials are also inconsistent with reform-based goals and thus need to be adapted to improve their overall quality.

Comfort Level with Curricular Analysis at End of Science Methods Course

At the end of the course, all of the interviewees said they felt comfortable analyzing science lesson plans, giving themselves a rating of a 4 or 5. For example, Karen, who initially rated her comfort level as a 2, gave herself a higher rating at the end of the course, saying:

> Now I would say I'm a 4. I'm not perfect at it. And I know that there are still some things I need to learn. But I think that I've come a long way and I feel much more comfortable. At the beginning when I got this lesson [in the pretest] I had no idea what to do. I did have some science background, so that was helpful. I feel like I maybe had a leg up from some other people, but I still had no idea what to

> look for, but now I feel like I have this set of things I can look for. (Karen, Interview 2)

Additionally, all of the interviewees who initially gave themselves a high rating at the beginning of the course explained that they naively did not realize at the time that they had much more to learn about analyzing science lesson plans. This perspective is exemplified in Ashley's response:

> Looking back I think I said at the time a 4. But now, I'd probably say I was a 2.5. I probably said something higher than I actually realized I was because I felt like I knew what I was doing 'cause I did feel like I had some skills coming into the classroom and didn't realize there were still some things that I needed to learn. But now since I've taken the course, I'd give myself a 4 'cause I feel like after learning about these criteria and learning how to go about looking at lessons, like what to look for and indicators to determine if it's meeting the criterion, I just feel like I know how to approach a lesson and have things in mind that I would want for the lesson to do. (Ashley, Interview 2)

There were two main factors influencing changes in preservice teachers' comfort level. First, by learning about specific reform-based criteria, the preservice teachers developed their knowledge for effective science teaching. This increased their ideas about how to analyze science lesson plans and thus their comfort level with this teaching task. For example, Chelsea explained how her analysis ideas expanded during the course, saying:

> At the beginning of the semester I could analyze [science lessons], but it was more narrow. It was focused on the things that I knew from last year like classroom management tools and stuff. But now I feel more comfortable and confident 'cause I have more ideas to consider when I'm analyzing lessons. (Chelsea, Interview 2)

Chelsea, like her peers, developed her ideas about how to teach science, which, in turn, increased her comfort level with analyzing science curriculum materials.

Second, the preservice teachers developed their pedagogical design capacity during the science methods course by repeatedly analyzing science lesson plans.

Engaging in curricular planning allowed them to act upon and with their newly developed knowledge about science teaching. For example, Shelley explained how engaging in the practice of curriculum materials analysis increased her comfort level with critiquing and adapting lesson plans. She said:

> I would just say the practice we had with critiquing lessons; just actually going through and doing it helped a lot. We didn't just do it once and then never do it again. We did it constantly throughout the semester. I mean it takes practice, so just going through and actually looking for some of these [criteria] really helped me feel more comfortable looking at a lesson plan. (Shelley, Interview 2)

This excerpt provides an example that shows that the preservice teachers pointed to changes in their pedagogical design capacity as contributing to increases in their comfort level with identifying strengths and weaknesses and making adaptations within curriculum materials.

Additionally, by the end of the science methods course, all of the interviewees, including Lisa who initially felt that the knowledge and authority of her cooperating teacher negatively impacted her comfort level, saw their cooperating teacher as a positive influence. The preservice teachers gave two main reasons for this perspective. All of them recognized that their cooperating teacher engaged in the practice of critiquing and adapting curriculum materials, leading them to conclude that it would be permissible, if not expected, for them to do the same. For example, when asked whether the knowledge and authority of her cooperating teacher negatively impacted her comfort level with analyzing curriculum materials, Shelley said, "Well, not really, because I don't think [my cooperating teacher] stuck very closely to some of these lessons herself" (Interview 2).

The other main reason for why the preservice teachers saw their cooperating teacher as a positive influence is because their teacher was supportive of their ideas and suggestions. For example, Lisa stated that she became comfortable analyzing her teacher's lesson plans because her cooperating teacher encouraged her to make the changes she wanted to make. She explained:

> Knowing that [my cooperating teacher] already made changes to the lesson, I initially was uncertain. So the first one I made some changes but I felt like, should I even be doing this? But once I actually got in there and did it, she said it went really well. And so for the second [lesson] with the moon, I think I felt more comfortable. I covered everything that she wanted me to cover but made changes I just felt helped made it more clear, like putting in an investigation question. She actually said, "That's something I don't really do enough of. I really appreciate that you found that and pulled it off." And then even for my math lesson, she has a very specific way of doing things. And I told her, "I want to stick to how you are in the classroom as much as possible." She said, "Really? I think that there are many ways of approaching the same goals." And so that was really comforting. I mean everybody is a different person and you can't try and be somebody else at the same time. So my CT was so supportive, and made me feel like it was okay to make changes. (Lisa, Interview 2)

Because the preservice teachers viewed their cooperating teacher as supportive of their ideas, they tended to perceive their cooperating teachers as having a positive, rather than a negative, influence on their comfort level with analyzing science curriculum materials.

Comfort Level with Curricular Analysis at End of Student Teaching Semester

It was uncertain whether the preservice teachers would continue to feel comfortable making modifications to lesson plans once they were no longer in the science methods course and were completely immersed in their classroom placements. Findings show that during their student teaching semester, the interviewees continued to critique and adapt curriculum materials, in general, and for those who had the opportunity to teach science, their science curriculum materials, specifically. This occurred even though, as discussed in Chapter 5, they did not always apply the reform-based criteria in their analyses. Karen demonstrated her level of comfort with engaging in curriculum materials analysis by describing numerous changes she made to her science lesson plans. She said:

> Kids had to design an experiment and the lesson had them do a lot of the work on their own. And I just knew that they would not be able to do it. So, what I did was change it so it was more whole group and we did a little bit more brainstorming on the board. And so I changed it so that the kids could get it. And I also added some questions at the beginning of the lesson as opposed to all of it at the end. Or like recording data, we'd record it on chart paper instead of an overhead. So lots of [changes], some of them weren't major changes, but basically every lesson, I would re-write every lesson to how it made sense for me. (Karen, Interview 3)

This excerpt was typical of other responses given by the preservice teachers with regard to how they planned with curriculum materials during their student teaching semester.

There was one exception to these findings. One preservice teacher, Lisa, did not make modifications to her science curriculum materials. Once in her cooperating teacher's classroom and no longer in the science methods course, Lisa again felt uncomfortable engaging in this teaching task due to her perceptions of the knowledge and authority of her cooperating teacher. She explained:

> I really stuck to hers and the reason was that she had adapted them from other places. And so it wasn't like she was giving me some copy out of one of these curriculum materials. She had already pieced them together and I didn't feel comfortable adapting her stuff. If it was my own classroom, I know I would have adapted them. There were changes that I would have made, but I didn't make them just because I felt funny doing it. And that was something I struggled with the entire time. (Lisa, Interview 3)

Similar to the beginning of the science methods course, Lisa felt uncomfortable analyzing science curriculum materials because she had to use lesson plans that her cooperating teacher had designed or modified herself. Even though Lisa perceived her cooperating teacher as supportive of her ideas during the student teaching semester, her perceptions of the knowledge and authority of her cooperating teacher were a stronger factor in shaping her comfort level.

Anticipated Comfort Level with Analyzing Curriculum Materials During First Year of Teaching

At the beginning of the science methods course, all of the interviewees explained that they planned on following their science curriculum materials closely during their first year of teaching, even though they believed it was important for teachers to critique and adapt their written resources. The preservice teachers gave three reasons for this response. Four interviewees said they would not feel comfortable making their own curricular decisions because of their limited teaching experience. Chelsea epitomized this perspective in the following excerpt, when she said, "My first year I might be a little bit nervous to go on my own and change things a lot. I might during my first couple years want to do it by the book until I get more experience with teaching" (Interview 1). Three preservice teachers said that they would first need to get to know their students before they would know what kind of adaptations they might want to make to their curriculum materials. Karen held this perspective, explaining, "I think with it being my first year, I'm likely to follow the materials pretty closely. But I think as the year progresses and if you understand what the kids will be able to do, you can make more adaptations" (Interview 1). One preservice teacher offered a third reason why she might follow her curriculum materials closely. Leah said that the way she would use her written resources would depend on how other teachers at their school used them, as illustrated in her response:

> I think I would have a harder time [modifying materials] if I knew that one of the teachers in my school did not alter the material and was really satisfied with it and thought that it was good because I think I would question my feelings towards it. Like I'm a new teacher so maybe I don't know necessarily what would work for the kids best. So I think I might not as openly question it as I would if I were in an environment where all of the teachers were like, "Oh, I like to do this sometimes and change this." Then I think I would be more comfortable questioning it. (Leah, Interview 1)

Here, Leah explained that the school climate would be an influential factor in determining whether she would modify her science curriculum materials or not. This perspective, along with the others, comprised the range of reasons that the interviewees gave at the start of the course for why they planned on following their materials closely during their first year of teaching.

By the end of the science methods course, all of the interviewees changed their perspective on curricular planning during their first year of teaching. They said they would feel comfortable analyzing their science curriculum materials from the very beginning of their teaching career. Chelsea exemplified this perspective in the following passage:

> I see myself using [my curriculum materials] often, taking advantage of what's there for me to use, but also being open minded about ways that I can change them if I feel that it would be helpful to my students or me as a teacher. So, I don't think I'll be afraid to do that even though I'm just a first year teacher. (Chelsea, Interview 2)

The preservice teachers maintained this perspective throughout their student teaching semester. For example, when asked how she sees herself using curriculum materials during her first year of teaching, Lisa said:

> As a first year teacher I think I'd really appreciate having [curriculum materials] to work with, just like as a springboard. I'd look through it and see what's there, but then also just bringing in my own stuff, cutting out what I think is not so useful…So yeah, just looking at the big goals, and seeing if it actually aligns with what I'm supposed to be covering and then enriching it where I need to, or changing it where I need to. So, probably a lot of changing going on, but still using a lot of what they give me. (Lisa, Interview 3)

These excerpts provide examples of the change in the preservice teachers' anticipated comfort level with analyzing science curriculum materials during their first year of teaching. At the end of the science methods course, all of the preservice teachers could see themselves making adaptations to their materials as new teachers, and they continued to uphold this perspective during their student teaching semester.

Summary

Four of the seven interviewees did not feel comfortable with critiquing and adapting science lesson plans at the beginning of the semester, largely because they felt that they had insufficient knowledge of science and science teaching, impacting their pedagogical design capacity. Only two interviewees felt uncomfortable modifying curricular plans due to their perceptions of the curriculum developers and cooperating teachers being of higher authority than themselves. By the end of the science methods course, all of the interviewed preservice teachers said they felt comfortable engaging in curricular planning. The main reasons that they gave for their increased comfort level were changes in their knowledge of science teaching and their pedagogical design capacity. Additionally, all of the interviewees modified their ideas about how they plan on using curriculum materials during their first year of teaching, coming to see themselves not as mere implementers but as curriculum designers. Finally, the majority of the interviewees felt comfortable designing curricular plans during their student teaching semester. Only one preservice teacher did not modify her placement materials, even though she identified weaknesses within them. This preservice teacher had received lesson plans that her cooperating teacher had designed or modified herself. As a result, the preservice teacher felt like she would be questioning the knowledge and authority of her cooperating teacher if she made changes to the lesson plans that she had received.

Conclusions

All of the interviewees viewed curricular analysis as an authentic aspect of teaching practice at the beginning of the science methods course, even though none of them had actually seen their previous cooperating teachers engaged in this task. They believed that teachers must adapt curriculum materials for their specific students, teaching styles, and standards. The preservice teachers held this belief, despite their observations, because they had developed a variety of reasons for why some teachers choose not to engage in this design work and why they themselves might not have had the chance to observe teachers engage in this practice.

At the beginning of the course, the preservice teachers also had limited beliefs about when, how, and why teachers engage in curriculum design. The science methods course and their work with their cooperating teacher helped the preservice teachers expand these beliefs in a number of ways. They learned that teachers adapt materials during planning, in addition to during and after instruction. They also came to recognize that teachers make changes within lesson plans, in addition to adding, supplementing, and omitting lessons. However, the science methods course and cooperating teachers communicated different beliefs about why teachers engage in curricular analysis. The course promoted the belief that teachers modify lesson plans to meet specific student needs, align with particular teaching styles, and improve how the subject matter is taught. The cooperating teachers modified for all of these reasons except the last one. Because of this discrepancy, only some preservice teachers adopted the belief that teachers adapt lesson plans to make them more consistent with reform goals and practices. Interestingly, those who did not adopt this belief did not use a criterion-based approach to analysis when completing their posttests.

With regard to their comfort level with curricular decision-making, only four of the seven interviewees said they felt uncomfortable engaging in this task at the beginning of the methods course. The main reason they cited for their low comfort level was their insufficient knowledge of science and science teaching and thus their limited pedagogical design capacity. The other three interviewees did not identify with these reasons. They recognized that they did not have strong subject matter knowledge but did not feel that this impacted their capacity to analyze science lesson plans. They also thought they had sufficient knowledge of science teaching developed from their experiences as science learners or did not see this type of knowledge as necessary for engaging in this teaching task. At the end of the science methods course, all of the preservice teachers said they felt comfortable engaging in the process of curriculum design. They all attributed their high comfort level to increases in their knowledge of science teaching and their pedagogical design capacity. Additionally, all but one of the preservice teachers continued to engage in curricular analysis during their student teaching semester. Finally, the preservice teachers' ideas about how they see themselves using curriculum materials during their first year of teaching shifted from curriculum followers to curriculum design makers.

In Chapter 7, I discuss the findings from this chapter and the previous two chapters and describe implications for theoretical frameworks on curriculum materials use, science teacher education, curriculum materials design, and future research.

CHAPTER 7

DISCUSSION AND IMPLICATIONS

Curriculum materials play a fundamental role in shaping classroom instruction, helping teachers make thoughtful decisions about practice. Effective teachers use curriculum materials as a guide, critiquing and adapting them in order to compensate for their weaknesses and address specific student needs and circumstances (Barab & Luehmann, 2003; Brown, 2009). Even though analyzing curriculum materials is an essential aspect of teaching practice, preservice teachers encounter many difficulties in doing so (Davis, 2006; Schwarz et al., 2008). To support preservice elementary teachers in developing beginning levels of proficiency in critiquing and adapting science curriculum materials, this dissertation focused on the use of reform-based criteria as tools to scaffold the development of an analytical stance toward curriculum materials. This chapter begins with a discussion of the findings from this study. Within this discussion, I describe the strengths and weaknesses in the design of the supports for helping preservice teachers develop their beliefs about and practices related to analyzing science curriculum materials. I conclude by describing theoretical insights into models for curriculum materials use and pedagogical content knowledge (PCK) for science teaching, implications for the design of science teacher education and curriculum materials, and future research directions.

Strengths in the Design of Supports for Analyzing Curriculum Materials

Using Reform-Based Criteria in the Analysis of Science Lesson Plans

During the science methods course, the preservice teachers had the opportunity to learn about a set of well-specified, standards-based criteria through readings and in-class activities and practice applying these criteria in their analysis of inquiry-oriented lesson plans. These criteria aimed to develop their capacity to analyze science curriculum materials in a principled, reform-based manner. These criteria were based on a simplified version of the AAAS Project 2061 analysis framework (Kesidou & Roseman, 2002; Stern & Roseman, 2004).

After learning about and applying the reform-based criteria in instructional planning, the majority of the preservice teachers experienced several positive changes in their pedagogical design capacity by the end of the science methods course. These individuals shifted from an unsystematic approach to a principled perspective on analysis. They also improved to some degree in their understanding and application of the different dimensions of PCK for reform-based science teaching that were foregrounded in the criteria. Additionally, the preservice teachers came to see the reform-based criteria as more important than their own criteria, which primarily dealt with the practical and affective aspects of science instruction, and when given the flexibility to determine the substance of their analysis, focused more on the reform-based criteria than on their own. They also tended to consider a wider range of reform-based criteria and engage in a more in-depth analysis with regard to these criteria by the end of the course. Overall, these findings show that preservice teachers are able to improve science curriculum materials to make them more reform-oriented when provided with an opportunity to learn about reform-based criteria.

These findings are noteworthy in light of a similar study, which found that preservice teachers had mixed success in learning about the reform-based criteria (Schwarz et al., 2008). In this study, Schwarz and colleagues (2008) had preservice teachers complete structured analysis forms when applying the reform-based criteria. When asked to evaluate the strengths and weaknesses of science curriculum materials at the end of the course, the preservice teachers made little spontaneous use of the reform-based criteria and instead based most of their curricular decisions on their own criteria. One reason for this finding is that they viewed the application of the reform-based criteria as "detailed and time-consuming" and "disconnected from the reality of the classroom" (p. 368). They also perceived little overlap between the reform-based criteria and their own goals and criteria. In contrast, the preservice teachers in this study tended to view the reform-based criteria as beneficial and relevant, motivating their use of the criteria. This may have occurred, in part, because the preservice teachers received a list of questions to consider, rather than a detailed analysis form, when applying each criterion. Additionally, they had the opportunity to make explicit connections between their own analysis ideas and the reform-based criteria. It is important to connect to preservice teachers' own ideas because what they bring ultimately mediates how they use curriculum materials and scaffolding tools in their analysis (Remillard, 2005). Overall, these findings suggest that having preservice teachers use a more simplified analysis framework that approximates what they might do more tacitly as practicing teachers and make connections between their own analysis ideas and the class criteria may encourage them to appropriate reform-based criteria as tools in their use of science curriculum materials.

The preservice teachers in this study also experienced greater confidence in their analysis capacities after using the reform-based criteria as lenses with which to interact with science curriculum materials. Specifically, their comfort level with analyzing curriculum materials increased by the end of the science methods course, and the interviewed preservice teachers continued to engage in curricular analysis during their student teaching semester. They also modified their ideas about how they see themselves using science curriculum materials during their first year of teaching. They initially planned on using curriculum materials as written during their first year of teaching, but by the end of the course, viewed curriculum design as an essential practice even for themselves as new teachers.

This finding is encouraging in light of reports that found that many preservice and new teachers do not critique their curriculum materials ahead of time or tailor them for their particular needs and purposes (Ball & Feiman-Nemser, 1988; Bullough, 1992; Grossman & Thompson, 2004; Lloyd & Behm, 2005; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Powell, 1997; Remillard & Bryans, 2004; Southerland & Gess-Newsome, 1999; Valencia et al., 2006). Instead, they tend to stick closely to the materials that they have been given, even when they are aware of limitations in the materials or recognize that the materials are not aligned with their beliefs about how the subject matter should be taught. A number of factors influence their decision to use their written resources in this way, including their need for concrete guidance about how to teach. Many of these preservice and new teachers had limited pedagogical design capacities for analyzing curriculum materials, constraining their ability to make decisions about what and how to teach and thus limiting their ability to overcome the inherent limitations of the original materials (Bullough, 1992; Grossman & Thompson, 2004; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Valencia et al., 2006). This study, in contrast, found that preservice teachers may engage in curricular analysis during student teaching and choose to continue to do so during their first year of teaching if they have opportunities to learn about reform-based criteria.

Engaging in Repeated Opportunities to Apply Criteria

The preservice teachers applied one of the reform-based criteria—'eliciting students' initial ideas and predictions'—across all three lesson plan analysis assignments. Applying the same criterion within different lesson plans enabled the preservice teachers to develop an improved understanding of the criterion over time, and by the posttest analysis, develop a more robust understanding of this criterion, in comparison to the other reform-based criteria. In fact, they demonstrated only weak or partial understanding of all of the criteria in their posttest analyses except for the repeated criterion, in which they demonstrated a more complete and in-depth understanding. Additionally, when allowed to determine the focus of their analyses, the preservice teachers applied the criterion 'eliciting students' initial ideas and predictions' more often than any other criterion. They also considered more indicators within this repeated criterion and thus engaged in a more in-depth analysis, in comparison to the other reform-based criteria.

These findings add to what we know about how to support preservice teachers in developing their PCK for science teaching and applying this knowledge in the critique and adaptation of science curriculum materials. Previous reports have found that having preservice teachers apply criteria only once within a scaffolded task resulted in mixed success in having the preservice teachers develop an understanding of the pedagogical ideas underlying the criteria (Schwarz et al., 2008) and use the criteria in subsequent analyses (Beyer & Davis, in press-a). This study extends these findings by providing concrete evidence for the idea that preservice teachers are able to enhance their pedagogical design capacity when provided with multiple opportunities to practice applying particular criteria before the scaffolds are faded. Specifically, they are able to expand their analysis ideas to include important dimensions of PCK for science teaching and develop their ability to attend to these ideas in their analyses. This finding is consistent with the perspective that the fading of scaffolds needs to be synchronized with the gradual development of learners' understanding rather than abruptly removed before learners are ready to complete the task on their own (Collins, Brown & Newman, 1989; Pea, 2004). Thus, this study shows that preservice teachers may need opportunities to apply the same criteria in multiple contexts with scaffolds gradually faded as preservice teachers develop their PCK for science teaching and their capacity to apply this knowledge in productive ways to their analysis tasks.

Participating in Authentic Analysis Experiences

The science methods course provided preservice teachers with the opportunity to apply their newly developed analysis ideas to the task of analyzing their own lesson plans that they were responsible for teaching in their field placements. Findings show that the preservice teachers demonstrated weaker understandings of the reform-based criteria in their analysis of their own lesson plans, in comparison to their analysis of inquiry-oriented lesson plans provided by their course instructor. One explanation for this difference is that the preservice teachers had the opportunity to choose their own analysis criteria when analyzing their own lessons, and in doing so, neglected to attend to several aspects of reform-based science instruction in their analysis. Another explanation is that the preservice teachers expressed additional alternative understandings of the criteria in analyzing their own lesson plans, in comparison to the inquiry-oriented lesson plans. This occurred, in part, because their own lesson plans, like many other existing science curriculum materials (Beyer et al., in press; Kesidou & Roseman, 2002; Stern & Roseman, 2004), were poorly aligned with reform-based standards and practices and thus reflected additional weaknesses (Forbes, in preparation). Thus, analyzing their own science lesson plans was a more challenging task than analyzing the inquiry-oriented science lesson plans.

These findings extend our understanding about how to support preservice teachers in transferring their knowledge and practices for curricular planning from in-class analysis assignments to more authentic analysis experiences. First, previous research has shown that the degree to which preservice teachers use particular criteria depends on whether the analysis task explicitly scaffolds their use or not (Davis, 2006). For example, Davis (2006) found that providing preservice teachers with a list of criteria representing complex ideas about science teaching enabled the preservice teachers to apply criteria not prominent in their own analysis ideas and thus engage in a more substantive analysis. This study corroborates this finding, showing that the preservice teachers did not automatically attend to the newly learned criteria in the absence of explicit reminders to do so in their analysis assignments. Second, this study extends existing research by providing insights into how preservice teachers use what they have learned from in-class analysis tasks to plan lessons for their students in their field placements. This study found that the preservice teachers tended to struggle with analyzing their own lesson plans—lesson plans that tended to be poorly aligned with reform-based science teaching (Forbes, in preparation)—even though the preservice teachers demonstrated several strengths in analyzing the inquiry-oriented lesson plans from the methods course. Similarly, Forbes (in preparation) found that a key factor impacting preservice teachers' ability to develop inquiry-oriented lesson plans was whether they started with quality curriculum materials or not.

Both of these findings support the argument that scaffolds need to be faded gradually as individuals are able to complete increasingly more aspects of the task on their own (Collins et al., 1989; Pea, 2004). Thus, this study shows that preservice teachers may need additional reminders to consider particular criteria in their analysis before giving them choice in their criteria selections. They may also need opportunities to practice analyzing low quality science lesson plans together as a class, in addition to inquiry-oriented lesson plans, before analyzing lesson plans from their field placements on their own.

Uncovering Cooperating Teachers' Planning Practices

During the science methods course, the preservice teachers had the opportunity to investigate their own cooperating teacher's planning practices. In their placement classrooms, the preservice teachers observed their cooperating teacher plan for instruction formally, as part of an assignment, and informally, as part of their field observations. The preservice teachers pointed to these experiences, in addition to their analysis experiences using reform-based criteria, as shaping their beliefs about curricular analysis. Specifically, these experiences helped the preservice teachers view curriculum materials analysis as an authentic teaching task and refine their beliefs about when, how, and why teachers analyze curriculum materials.

At the beginning of the science methods course, the majority of the interviewed preservice teachers recognized that teachers modify their materials during and after instruction but did not mention that teachers also engage in design work before instruction. One possible explanation for this finding is that they viewed instructional planning merely as a time to prepare for the lesson activities (e.g., gather materials, make copies of worksheets, set up experiments) rather than as a time to critique and adapt curriculum materials. The preservice teachers also focused on the large-scale changes that teachers make to lessons and units (e.g., adding, supplementing, and omitting lessons) at the exclusion of focusing on the small-scale changes within lesson plans (e.g., changing the materials used, increasing student control over an activity, making the lesson purpose explicit to students). Additionally, the preservice teachers expressed a limited set of reasons for why teachers engage in design work, which focused on the contextual and personal changes that teachers make to lesson plans.

By the end of the methods course, all of the interviewed preservice teachers mentioned that they had seen their cooperating teachers modify their written resources, contributing to their belief that curricular analysis is an authentic teaching task. Through their classroom observations and analyses experiences, they also came to view curriculum design work as a task that takes place before instruction and that includes both large- and small-scale changes. Additionally, some (not all) of the preservice teachers expanded their beliefs to include the idea that teachers modify materials to make them more consistent with reform-based standards and practices—changes that are independent of specific individuals and contexts.

Previous studies have reported on preservice teachers' beliefs about curriculum materials analysis (e.g., Bullough, 1992; Nicol & Crespo, 2006; Schwarz et al., 2008; Valencia et al., 2006), but none of these studies have focused specifically on the dimensions described here. Therefore, the findings in this study extend what we know about some of the beliefs that preservice teachers may have about curricular analysis, specifically with regard to their ideas about when, how, and why teachers engage in this design work. Additionally, other studies have shown that preservice teachers who do not have the opportunity to observe their cooperating teacher engage in curricular analysis may develop the belief that critiquing and adapting are inauthentic practices when planning for science instruction (Gunckel & Tsurusaki, 2006; Nicol & Crespo, 2006) This study extends these findings by providing explicit evidence for the idea that preservice teachers may develop more complete beliefs about curriculum materials analysis if they have opportunities to learn about classroom teachers' planning practices, in addition to engaging in curricular analysis experiences themselves.

Limitations in the Design of Supports for Analyzing Curriculum Materials

Even though the preservice teachers had the opportunity to learn about a criterion-based approach to analysis and about reform-based criteria, specifically, roughly one-third of the preservice teachers, including three of the seven interviewees, continued to use an unsystematic or sequential approach in their posttest analyses. These individuals also attended to few of the ideas underlying the reform-based criteria in their posttests analyses. Therefore, the analysis ideas that they discussed in their posttests differed little from the ideas in their pretests.

As for the individuals who had demonstrated reform-based, analytical stances toward participating with curriculum materials during the science methods course, all of them who were interviewed returned to an unsystematic approach to analysis when engaging in curricular planning during the student teaching semester. These individuals also demonstrated a renewed focus on their own analysis criteria, reducing their use of the reform-based criteria emphasized in the course. In fact, they only focused on two dimensions of reform-based science teaching: ‘attending to learning goals’ and ‘making science accessible to all students.’ Thus, with the exception of learning goals and students, the preservice teachers tended to focus on their own criteria, which emphasized the practical and affective aspects of instruction, when planning for science instruction during their student teaching semester.

One explanation for these findings is that the preservice teachers did not fully develop their pedagogical design capacity for engaging in curricular analysis during their student teaching semester. The methods course provided them with the opportunity to develop beginning level knowledge and skills with critiquing and adapting science curriculum materials but did not adequately prepare them to engage in these teaching tasks on their own or in using the curriculum materials in their field placements, which tended to be poorly aligned with the goals and practices of reform-based science teaching (Forbes, in preparation). For example, the revised lesson plans that the preservice teachers developed on their own in their posttest analyses did not address many aspects of reform-based science teaching, even though their posttests were significantly better than their pretests. Additionally, when analyzing the lesson plans from their field placements, the preservice teachers tended to face additional struggles in overcoming the weaknesses in the materials, in comparison to their analysis of the inquiry-oriented lesson plans provided by their course instructor. They demonstrated these weaknesses in both of these analysis tasks, in part, because the preservice teachers did not think to or did not see the value in attending to particular aspects of reform-based science teaching in their analyses. When they did attend to the reform-based criteria, they expressed a variety of alternative ideas about these criteria, demonstrating limitations in their understandings of reform-based science teaching. These findings suggest that the scaffolds within the methods course may have been faded too quickly, before the preservice teachers had the opportunity to develop the understandings and capacities needed to engage in less structured, and thus more challenging, analysis tasks.

Another explanation for these findings is that the reasons communicated by the preservice teachers' cooperating teachers about *why* teachers engage in design work differed from the reasons promoted in the science methods course. The course emphasized the importance of modifying materials to make them more consistent with reform-based goals and practices, but few preservice teachers perceived their cooperating teachers modify materials for this reason. Instead, most of them only observed their cooperating teachers make adaptations for their specific context, students, teaching styles, and standards. Because of this discrepancy, some interviewees, whose cooperating teachers moderated the impact of the course, disregarded the belief that teachers adapt materials to improve their overall quality—changes that are independent of specific needs and contexts. As a result, these preservice teachers did not tend to see the reform-based criteria as relevant and thus prioritized few in their posttest analyses. As for those interviewees who did refine their beliefs about why teachers engage in design work, they tended to model their planning practices after their cooperating teacher's once they were no longer in the science methods course rather than on their own beliefs about curricular analysis. As a result, they did not use a criterion-based approach to analysis and deemphasized the ideas underlying the reform-based criteria in their analysis, except for those ideas that they saw their cooperating teachers attend to in their analyses—criteria related to learning goals and students.

These findings extend what we know about how to support preservice teachers in developing their pedagogical design capacity for analyzing curriculum materials and applying their newly developed capacities within the context of the elementary school classroom. Previous research has shown that preservice teachers may experience differing perspectives between their methods courses and placement classrooms with regard to the role of curriculum materials in authentic practice (Nicol & Crespo, 2004; Schwarz et al., 2008). For example, in the study by Schwarz and colleagues (2008), their science methods courses aimed to develop the preservice teachers' capacities to engage in curricular analysis, but none of the preservice teachers viewed this task as authentic or relevant, in part, because they did not observe their cooperating teachers engaged in this practice. Similarly, the preservice teachers in this study experienced a disconnect between what they learned in their methods course and what they experienced in their placement classrooms. However, this disconnect did not deal with the authenticity of curriculum materials analysis as a teaching practice, but rather, with the reasons *why* teachers engage in this design work. Therefore, this study shows that preservice teachers' beliefs about why teachers analyze curriculum materials may impact whether they adopt a criterion-based approach to analysis or not. This study also extends our understanding about how to support preservice teachers by highlighting particular disconnects that preservice teachers may experience as they navigate different contexts.

Summary

After having the opportunity to learn about and apply reform-based criteria during the science methods course, the preservice teachers developed aspects of their pedagogical design capacity for curricular planning. Many of them adopted a criterion-based approach to analysis, expanded their analysis ideas, and refined their beliefs about curricular analysis, especially when they had the opportunity to practice applying the same criteria using different lesson plans. Despite these positive outcomes, the preservice teachers struggled with engaging in authentic analysis tasks during the course and maintaining a principled, reform-based approach to analysis during their student teaching semester. This may have occurred, in part, because the scaffolds within the course were faded too quickly before the preservice teachers developed the capacity to engage in curricular planning on their own using curriculum materials from their field placements, which tended to be poorly aligned with reform-based science teaching goals. This finding may also have occurred because their cooperating teachers expressed different reasons for adapting curriculum materials than what was presented in the course. The methods course emphasized the importance of modifying materials to make them more consistent with reform-based standards and practices, but few preservice teachers observed teachers modify materials for this reason. In sum, the preservice teachers experienced important gains in their capacity to analyze curriculum materials during the methods class, though the gains were not long-lasting in all cases.

Theoretical Implications of the Study

The findings from this study shed light on models of science teacher knowledge, highlighting particular alternative ideas within beginning elementary teachers' knowledge base for science teaching. This study also provides insights into models on curriculum materials use, adding specificity and shedding light on new factors for inclusion. I present these implications in the sections below.

Theoretical Insights into Science Teacher Knowledge

Magnusson and colleagues (1999) outlined a model of PCK for science teaching that highlighted five particular components within this knowledge domain (originally presented in Figure 2.3). Since then, several studies have described the strengths and weaknesses of preservice and new teachers' knowledge within this domain (e.g., Southerland & Gess-Newsome, 1999; van Driel et al., 1998; Zembal-Saul et al., 2000). Drawing upon the analyses of preservice teachers' applications of the reform-based criteria, this study extends this work by highlighting particular alternative ideas that novice teachers may have with regard to three of the components within PCK for science teaching: knowledge of science-specific curricula, assessment, and instructional strategies. Additionally, this study sheds light on potential weaknesses in beginning teachers' general pedagogical knowledge and knowledge of scientific inquiry—essential ingredients for developing PCK (Abell, 2007; Grossman, 1990; Magnusson et al., 1999).

First, this study describes particular alterative ideas that beginning teachers may have about science curriculum materials—specifically, about the learning goals within them. Beginning teachers may assume that learning goals are necessarily connected to state and district standards. In other words, they may believe that local adoption of a particular set of curriculum materials means that they can blindly use the materials without checking for alignment with their district or state standards. Additionally, beginning teachers may assume that the learning goals within lesson plans are automatically connected with assessments provided within curriculum materials and thus not recognize that some materials may not provide a way to assess every learning goal, and if they do, may not have an adequate way in which to do so. One possible explanation why beginning teachers may make these assumptions is they take the curriculum materials as a given. For example, they may express these naïve ideas if they view the curriculum materials as high quality because they are published (Ball & Feiman-Nemser, 1988; Ben-Peretz, 1990), they perceive that experts have developed the curriculum materials (Ben-Peretz, 1990; Bullough, 1992; Schwarz et al., 2008), or their school district has mandated their use.

Second, beginning teachers may have limited knowledge about science assessment, including what to assess and how to assess—both components within Magnusson and colleagues' (1999) model of PCK for science teaching. In considering what dimensions of science learning to assess, novice teachers may focus on assessing an individual student's content understandings at the exclusion of assessing his or her inquiry abilities and understandings. In deciding what methods to use, beginning teachers may assume that the worksheets provided within curriculum materials always enable teachers to assess all aspects of student learning—including both content understandings and inquiry abilities. Some beginning teachers may also mistakenly think that having students' apply their newly developed knowledge means having them use what they had learned from an experiment or reading to complete a worksheet directly related to the in-class activity rather than to complete a new task. Additionally, novice teachers may assume that they can draw conclusions about an individual student's learning from assessments focused at the whole-class level. One explanation for these limited ideas about science assessment is that beginning teachers tend not to spend much time thinking about learners and learning (Fuller, 1969; Furlong & Maynard, 1995; LaBoskey, 1994). Instead, they tend to focus on themselves as teachers, developing their knowledge and skills for teaching and focusing on how well they enact lessons. As a result, beginning teachers may not spend much thinking about what dimensions of science learning to assess, what evidence to gather for student learning, and how to respond to learners.

Finally, this study highlights potential limitations within beginning teachers' knowledge about science-specific instructional strategies—another important component of PCK for science teaching. For example, beginning teachers may struggle with eliciting students' predictions, providing experiences with phenomena, and engaging students in developing evidence-based explanations. They may also demonstrate limited strategies for making science accessible to all students and helping students make connections among their prior knowledge, experiences with the phenomena, and the science concepts. Several explanations help account for these findings. These explanations relate to potential weaknesses in novice teachers' general pedagogical knowledge and subject matter knowledge—domains of teacher knowledge that influence the development of PCK (Abell, 2007; Grossman, 1990; Magnusson et al., 1999)—as described next.

Beginning teachers may have naïve ideas related to their pedagogical knowledge about learners and learning, contributing to their limited knowledge of science-specific instructional strategies. Specifically, they may assume that all students can learn if they are simply provided with generalized forms of support. For example, the preservice teachers in this study thought that all students are able to experience success with learning science if they are simply provided with generalized forms of help—such as, having the teacher model how to do an experiment or circulate among students as they work independently. They did not recognize that students may also need more individualized forms of support. Additionally, beginning teachers may assume that when students learn science, they are always able to make connections among ideas without support. For example, the preservice teachers did not typically help students connect the lesson purpose to students' own lives. They rarely had students revisit their initial ideas and predictions at the end of lessons, and they did not tend to help students make connections between the newly learned scientific ideas and their personal, cultural, and social experiences. Instead, they assumed that students would make these connections on their own without explicit support. Past studies have shown that preservice teachers often do not consider students and student learning very extensively or in very sophisticated ways (Southerland & Gess-Newsome, 1999; Zembal-Saul et al., 2000). This study supports this idea by highlighting two particular alternative ideas that beginning teachers may express with regard to their understanding of learners and learning.

Another explanation for why beginning teachers may have limited knowledge of science-specific instructional strategies is inadequate subject matter knowledge, specifically with regard to understanding the different dimensions of scientific inquiry. For example, the preservice teachers in this study equated students' predictions about the phenomena with students' initial ideas about the new content. They also had alternative ideas about what it means to provide students with multiple experiences with phenomena, which the course defined as providing a range of first- and second-hand experiences with real-world phenomena as well as relevant instructional representations (Kesidou & Roseman, 2002; Stern & Roseman, 2004). Some interpreted this inquiry feature to mean having students experience different components of a lesson plan—for example, completing a worksheet, engaging in a hands-on activity, and participating in discussions. Others thought it meant having students experience different learning styles—auditory, visual, and kinesthetic. The preservice teachers also demonstrated a range of ideas with regard to having students develop scientific explanations, which the course, in line with the science education research literature (e.g., McNeill, Lizotte, Krajcik, & Marx, 2006), defined as supporting a claim with evidence. Some of them thought that having students share what they have learned at the end of class or having students share their ideas out loud elicited scientific explanations. Others thought that having students state a claim but without evidence counted as explanation construction. Other studies have similarly found that preservice teachers tend to have undeveloped or unrefined ideas about scientific inquiry (Haefner & Zembal-Saul, 2004; Smith & Anderson, 1999). The way in which teachers understand scientific inquiry directly impacts their knowledge of instructional strategies for promoting scientific inquiry and thus whether reform-based teaching is promoted or hindered in the science classroom. Unfortunately, little is known about teachers' knowledge and beliefs about scientific inquiry (Davis et al., 2006). This study adds to what we know about these teacher characteristics by highlighting particular alternative ideas that beginning teachers may have about specific inquiry practices.

Despite these limitations in preservice teachers' PCK for science teaching, it is important to note that developing a knowledge base for science teaching takes time and that the preservice teachers in this study were just beginning to learn about what it means to teach science. Thus, it is reasonable that the preservice teachers struggled in the ways that they did as they developed their PCK for science teaching during the course of just one semester. Additionally, the preservice teachers likely had additional strengths with regard to their PCK for science teaching than what the analysis tasks measured in this study since these tasks were designed to measure preservice teachers' knowledge-in-action and not simply their knowledge.

Theoretical Insights into the Teacher-Curriculum Participatory Relationship

Both the teacher and the curriculum materials participate in the design of the planned curriculum (Brown, 2009; Remillard, 2005). On the one hand, curriculum materials specify what science is important to teach and what methods are essential for teaching it, thereby serving as tools in the development of curricular plans. On the other hand, teachers possess a unique set of experiences, beliefs, knowledge, and goals, which mediate how they use the curriculum materials in planning for and enacting instruction. Thus, teachers and curriculum materials simultaneously shape and are changed through this participatory relationship. This partnership between teacher and curriculum materials is depicted in Remillard's (2005) teacher-curriculum participatory relationship model in Figure 7.1 (originally presented in Figure 2.1).

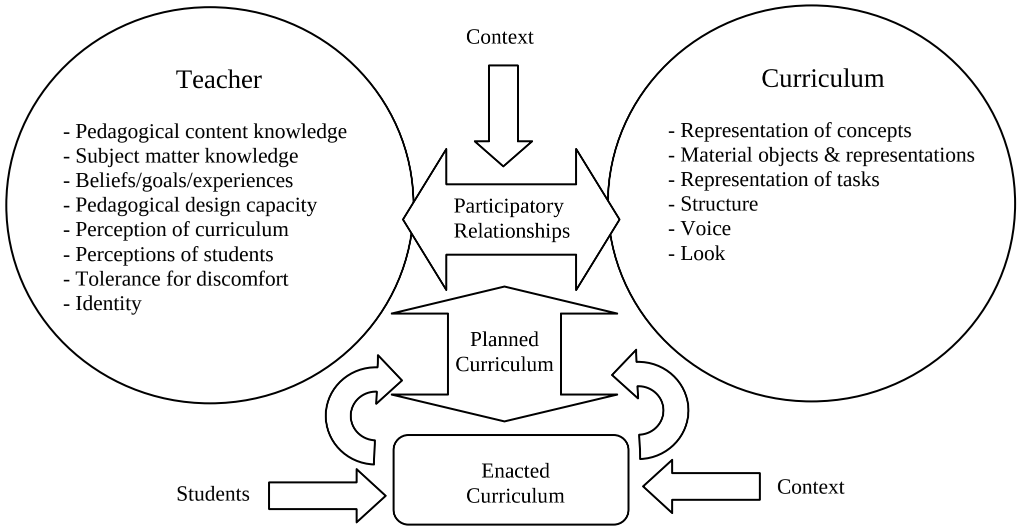

Figure 7.1. Model of the participatory relationship between teacher and curriculum materials (Remillard, 2005).

This dissertation examined specific components of this participatory relationship model within a particular context. Specifically, the 'teachers' in this study included preservice elementary teachers, and the 'curriculum' focused on science curriculum materials. Additionally, this study centered on two particular design practices—critique and adaptation as associated with the design of the planned curriculum. Within this particular context, the findings in this study provide insights into Remillard's (2005) model of teachers' participation with curriculum materials, adding specificity to some of the model components and providing suggestions for additional factors to be incorporated.

This study's findings provide additional detail about the material resources in the model. Specifically, the degree to which curriculum materials are aligned with reform-based standards and practices may influence beginning teachers' interactions with the materials. For example, this study found that the preservice teachers engaged in more productive analyses when they analyzed inquiry-oriented science lesson plans versus science lesson plans that tended to be less consistent with the goals of reform-based science teaching. Similarly, in his study with the same preservice elementary teachers, Forbes (in preparation) found that the curriculum materials were by far more influential than the preservice teachers' self-efficacy, preferences for science teaching, and science background in shaping their curricular planning practices. Thus, this particular aspect of science curriculum materials may influence the extent to which preservice teachers are able to develop high-quality curricular plans for students.

Findings also suggest adding specificity to some of the teacher resources listed in the model. These teacher resources may mediate how beginning teachers not only use curriculum materials in developing curricular plans but also how they understand and use reform-based criteria in their analyses. As described above, beginning teachers' PCK for teaching both science topics and scientific inquiry practices may shape their ability to accurately apply reform-based criteria in their analysis. Likewise, their general pedagogical knowledge and their subject matter knowledge—as related to their understanding of scientific inquiry—may also play a role in shaping their curricular practices. With regard to their beliefs, goals, and experiences, novice teachers' own criteria and goals for science teaching may influence what they focus on in their analyses. Their beliefs about when, how, and why teachers analyze curriculum materials may also shape their ideas about the role of curriculum materials in teaching science and their relationship with the materials. In regard to their tolerance for discomfort, beginning teachers' comfort level for analyzing science curriculum materials may determine whether they view curricular decision-making as a stabilizing experience or not. Finally, this study also emphasized the importance of the role of pedagogical design capacity in shaping beginning teachers' ability to use their personal and material resources to critique and adapt science curriculum materials in productive ways. Specifically, this capacity may shape the degree to which beginning teachers engage in a principled, reform-based approach to analysis when creating learning opportunities for students.

In addition to adding specificity to some of the existing components in the participatory relationship model, the findings from this study also suggest new factors to consider. One component includes the use of tools to scaffold preservice teachers' analysis of curriculum materials. This study examined the use of reform-based criteria as one example of such a tool. Findings showed that the use of criteria may help beginning teachers learn about different dimensions of effective science teaching and consider these dimensions in their analysis of science curriculum materials. Another component to incorporate into the model includes the multiple contexts in which preservice teachers navigate. This study focused specifically on the science methods course and the field placement classroom. Findings showed that different contexts may hold conflicting perspectives on curriculum materials use in the science classroom, shaping the ways in which beginning teachers interact with curricular resources. Figure 7.2 depicts a modified model of the teacher-curriculum relationship that includes these components—scaffolding tools and multiple contexts—and the additional specificity of teacher and material resources within the context of preservice elementary teachers critiquing and adapting science curriculum materials in the design of the planned curriculum.

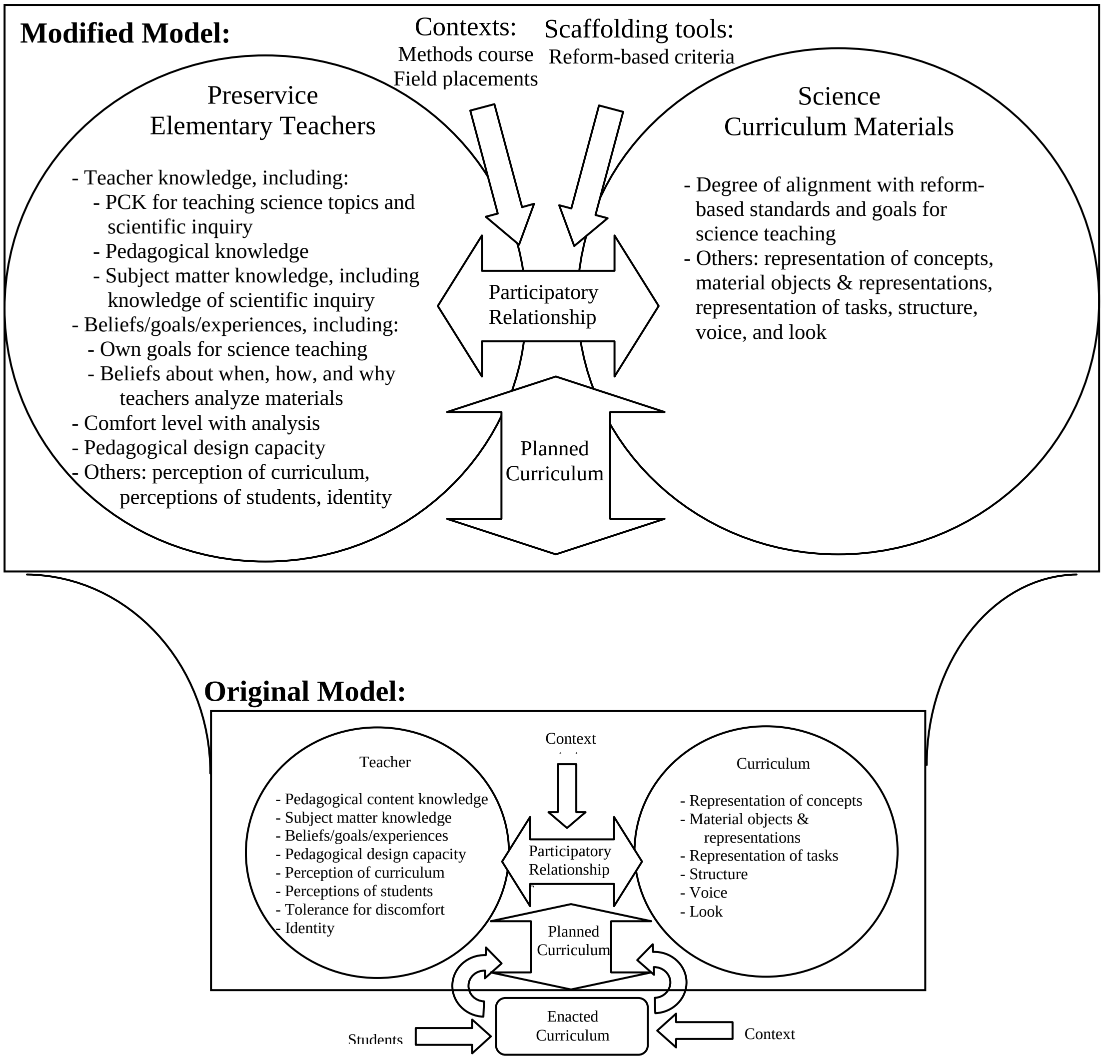

Figure 7.2. Modified model of the participatory relationship between teacher and curriculum materials (Remillard, 2005).

Overall, this model shows that the subjective meanings embedded within science curriculum materials and the use of scaffolding tools mediate the teacher-curriculum relationship by enabling or constraining preservice elementary teachers' actions as they develop curricular plans. Likewise, the resources that preservice teachers draw upon and the communities in which they participate shape how they use the curriculum materials and scaffolding tools in the design of the planned curriculum.

Implications for Supporting the Development of Preservice Teachers' Pedagogical Design Capacity for Analyzing Curriculum Materials

The findings from this study also have important implications for fostering the development of pedagogical design capacity for analyzing science curriculum materials. In the following sections, I discuss implications for the design of science teacher preparation and induction programs, suggesting particular experiences to help beginning teachers develop beginning-level knowledge and skills for critiquing and adapting lesson plans and refine their beliefs about curricular analysis. I then discuss how this work informs the design of curriculum materials themselves. I conclude by presenting ideas for future research directions.

Design Implications for Teacher Preparation and Induction

Preservice and new teachers need opportunities to see design work as authentic aspects of their job as teachers and develop their pedagogical design capacity for analyzing curriculum materials (Ball & Feiman-Nemser, 1988; Bullough, 1992; Davis, 2006; Grossman & Thompson, 2004; Lloyd & Behm, 2005; Lynch, 1997; Nicol & Crespo, 2006; Powell, 1997; Schwarz et al., 2008; Valencia et al., 2004). By learning how to become effective decision makers, they will be able to overcome the inevitable limitations of curriculum materials, and in turn, provide worthwhile learning experiences that promote student learning. Teacher educators play a key role in helping preservice and new teachers develop beginning levels of proficiency with this teaching practice.

In this section I outline a set of instructional goals for teacher educators who aim to help beginning teachers develop their knowledge, beliefs, and abilities dealing with curriculum materials analysis. These goals are informed by the challenges that preservice and new teachers face in analyzing curriculum materials for effective science teaching.

For each instructional goal, I then present specific instructional strategies informed by the research literature and findings from this study. These strategies are intended to help teacher educators make informed decisions about how to foster effective participation with curriculum materials within teacher preparation programs. Some of these instructional strategies are relevant for the design of teacher induction programs as well. And although these strategies are informed by findings from a science methods course, these strategies may also be useful in the design of methods courses in other fields. Table 7.1 provides a summary of these instructional goals and strategies.

Table 7.1
Summary of Instructional Goals and Strategies for Science Teacher Educators Supporting the Development of Pedagogical Design Capacity

Instructional Goals	Instructional Strategies	Teacher Preparation (P) & Induction (I)
Develop pedagogical design capacity for analyzing science curriculum materials.	Identify their own analysis ideas.	P, I
	Learn about criteria related to the goals of reform-based science teaching.	P, I
	Apply reform-based criteria in multiple analyses.	P, I
	Analyze multiple lesson plans of increasingly poorer quality before analyzing science lesson plans from their field placements.	P
	Work with teachers who express a principled, reform-based stance toward materials.	P, I
Expand beliefs about when & how teachers analyze materials.	Design curricular plans.	P, I
	Investigate when and how teachers engage in curriculum materials analysis.	P, I
Expand beliefs about why teachers analyze curriculum materials.	Connect criteria to reform-based standards.	P, I
	Identify strengths and weaknesses within published curriculum materials.	P, I
	Examine reviews of curricular programs.	P, I
	Observe teachers adapting materials to make them more consistent with reform-based standards and practices.	P, I
	Interview focus group of teachers about the reasons why they adapt their materials.	P

Developing pedagogical design capacity for analyzing science curriculum materials. Without support, preservice and new teachers may consider a limited set of ideas when they design curricular plans, focusing primarily on the practical and affective aspects of instruction (Beyer & Davis, in press-a; Bullough, 1992; Lloyd & Behm, 2005; Nicol & Crespo, 2006; Schwarz et al., 2008). Other beginning teachers may stick closely to their curriculum materials, even when they recognize weaknesses within them, because they have limited knowledge about how to overcome their limitations (Grossman & Thompson, 2004; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Valencia et al., 2006). Therefore, teacher educators need to help preservice and new teachers develop their understanding of reform-based science teaching and their pedagogical design capacity for analyzing curriculum materials to promote effective science teaching. Specifically, teacher educators can have beginning teachers:

- *Identify their own analysis ideas.* Preservice and new teachers enter instruction with their own ideas about how to analyze science lesson plans (Davis, 2006; Schwarz et al., 2008). Teacher educators should elicit these ideas when they introduce preservice and new teachers to the task of curriculum design. Specifically, this study found that teacher educators should elicit these ideas by asking beginning teachers to describe their ideas about key components of a science lesson. This instructional strategy is more likely to elicit a broader range of productive ideas for curricular analysis than simply having them critique and adapt an actual lesson plan or having them share their ideas about analysis criteria or about effective science teaching. Eliciting beginning teachers' ideas can help them recognize that they themselves have standards for making judgments about the quality of science curriculum materials. This, in turn, can help create buy-in for learning about and adopting a criterion-based approach to analysis. Their analysis ideas can also serve as leveraging points for learning about additional criteria related to reform-based science teaching.

- *Learn about criteria related to the goals of reform-based science teaching*. Many existing science curriculum materials do not represent effective science teaching (Beyer et al., in press; Forbes, in preparation; Kesidou & Roseman, 2002; Stern & Roseman, 2004) and thus need to be adapted in order to make them more consistent with reform-based standards and practices. To help beginning teachers engage in this design work, teacher educators should help them develop their understanding of reform-based science instruction by introducing them to criteria representing effective science teaching and having them unpack the intended meanings of these criteria through use. This study found that learning about such criteria can support beginning teachers' curricular interactions by providing lenses with which to interact with science curriculum materials in productive ways. To help preservice and new teachers learn about and apply reform-based criteria, teacher educators should have them
    - *First explore criteria that are aligned with their initial ideas about science teaching.* Leveraging these ideas can promote accurate application of the reform-based criteria, as was the case in this study, when the preservice teachers were asked to 'attend to learning goals' and 'establish a sense of purpose' in their analyses.

    - *Subsequently explore reform-based criteria that expand their initial analysis ideas.* Because preservice and new teachers also have undeveloped and unsophisticated ideas about science teaching and thus limited analysis ideas, teacher educators should help them identify gaps and limitations in their ideas by introducing them to new reform-based criteria and emphasizing the importance of attending to these criteria in their analyses. This study found that this can help beginning teachers develop a more robust understanding of effective science teaching and more extensive ideas for analyzing science lesson plans.

- *Apply the reform-based criteria in multiple analyses.* Preservice and new teachers tend to develop weak or partial understandings of new criteria when they only have one opportunity to practice applying the criteria in their analysis of science lesson plans. This study also found that beginning teachers do not readily attend to these new criteria when given choice in their criteria selections. Thus teacher educators should have preservice and new teachers apply the same criteria in their analysis of multiple lesson plans that highlight different strengths and weaknesses with regard to the criteria. This study found that these curricular experiences can provide beginning teachers with the opportunity to visualize the criteria in different ways and thus develop a more robust understanding of the different dimensions of reform-based science teaching foregrounded in the criteria. This, in turn, can help them see the importance of the criteria, leading them to choose these criteria more often in more open-ended analyses.

- *Analyze multiple lesson plans of increasingly poorer quality before analyzing science lesson plans from their field placements*. Lesson plans from elementary school classrooms are often inconsistent with reform-based science teaching (e.g., Forbes, in preparation). This study found that this poses a very challenging analysis task for preservice teachers, especially if they have not had scaffolded opportunities to analyze such materials. Thus teacher educators should have preservice teachers apply reform-based criteria in their analysis of a range of lesson plans that vary in the extent to which they align with reform-based norms and practices. Analyzing science lesson plans of increasingly poorer quality enables preservice teachers to engage in analysis tasks that are incrementally more complex, and in turn, support them in developing their pedagogical design capacity for analyzing curriculum materials. This experience can also prepare preservice teachers for the uncertainties of their classroom context where they may be given curricular resources that do not represent effective science teaching.
- *Work with teachers who express a principled, reform-based stance toward curriculum materials*. This study found that the reasons why cooperating teachers analyze their curriculum materials may influence whether preservice teachers see reform-based criteria as useful or not. Specifically, the preservice teachers did not modify their lesson plans to make them more consistent with reform-based standards and practices because they did not see their cooperating teachers make adaptations for this particular reason. Thus teacher educators should provide opportunities for preservice and new teachers to work with cooperating/mentor teachers who use ideas related to the reform-based criteria in their design work.

This can help preservice and new teachers experience consistent norms around the use of curriculum materials between their methods courses and field placements, and in turn, help them further develop their pedagogical design capacity during and following the methods course.

Expanding beliefs about when and how teachers analyze curriculum materials. Without support, preservice and new teachers may believe that curriculum development occurs only during and after instruction and that teachers make only wholesale changes to their materials—adding, supplementing, or omitting lessons. Thus, teacher educators need to help beginning teachers expand their limited beliefs about when and how teachers engage in curricular analysis. Specifically, they need to help preservice and new teachers recognize that teachers make different types of modifications to their lesson plans, including both extensive and more nuanced adaptations. They also need to guide preservice and new teachers to see that curriculum design pervades all aspects of practice—in preparing for instruction, teaching the lesson, and reflecting upon the enactment. To address these goals, teacher educators can provide beginning teachers with opportunities to:

- *Design curricular plans*. Teacher educators should have preservice and new teachers modify existing lesson plans, like in this study, while making explicit that they are engaged in design work during the planning phase of instruction and that their curricular adaptations include both small- and large-scale changes. This can help beginning teachers to develop an understanding about when and how teachers modify materials.

- *Investigate when and how teachers engage in curriculum materials analysis*. On their own, preservice and new teachers do not readily discern the ways in which teachers use their curriculum materials. This study found that encouraging beginning teachers to have conversations with and make observations of teachers who engage in the process of curriculum development can help them expand their ideas about when and how teachers modify their curriculum materials. Therefore, teacher educators should provide opportunities for beginning teachers to investigate other teachers' curricular planning practices in order to help them expand their beliefs about when and how teachers use curriculum materials.

Expanding beliefs about why teachers analyze curriculum materials. On their own, preservice and new teachers may believe that the only reasons that teachers modify curriculum materials are to address specific students' needs, local standards, and their own teaching style, as evidenced in this study. Thus teacher educators need to help beginning teachers expand their beliefs about why teachers engage in curriculum materials analysis. Specifically, this study found that beginning teachers need help seeing that materials need to be modified to make them more consistent with reform-based standards and practices—changes that are independent of specific needs and contexts. Even though this study identifies this an important area in need of support, it does not provide evidence for what instructional strategies might be the most useful for helping beginning teachers develop more sophisticated beliefs. Therefore, I present the following list of instructional strategies only as recommendations to teacher educators with the caveat that these strategies need to be further explored. To help beginning teachers expand their limited beliefs, teacher educators can have them:

- *Connect criteria to reform-based standards.* Teacher educators can have preservice and new teachers make explicit connections between reform-based criteria and standards for science content and teaching. Beginning teachers can examine standards documents, such as the *National Science Education Standards* (NRC, 1996), to find out what students are expected to know and do in science as well as uncover what they should understand and be able to do as teachers of science. Then preservice and new teachers can make connections between these standards and the criteria they use for making judgments about the quality of lesson plans. This experience may help them see that it is important for all teachers to consider the reform-based criteria and that the application of the criteria is not dependent on personal preference and choice. This, in turn, may help them see that teachers modify materials to improve their overall quality, in addition to addressing specific student needs and circumstances.
- *Identify strengths and weaknesses within published curriculum materials*. Preservice and new teachers can critique published curricular resources using reform-based criteria. This experience can enable them to identify weaknesses in the materials, enabling teacher educators to highlight the idea that published materials are not necessarily aligned with reform-based standards and practices and thus need to be modified in order to improve how the subject matter is taught. Equally important, engaging in curricular analysis of published resources can enable preservice and new teachers to identify their strengths, helping them see that published curricular offerings, though they may contain weaknesses, are important resources for developing plans for instruction.

- *Examine reviews of curricular programs*. To further help preservice and new teachers recognize that published curriculum materials are not without weaknesses, teacher educators can have them examine curriculum evaluation reports. Exploring reviews may help them see that many published materials fail to address reform-based standards, and in turn, help them recognize that one of the reasons that teachers modify materials is to align them with the goals of reform-based science teaching. However, to prevent beginning teachers from becoming overwhelmed by the number of weaknesses within materials and experiencing curriculum materials analysis as a destabilizing experience, teacher educators can also highlight the strengths within curricular programs and show that some programs are stronger resources for teachers than others.
- *Observe teachers adapting materials to make them more consistent with reform-based standards and practices*. Teacher educators can provide opportunities for preservice and new teachers to observe teachers attending to the ideas underlying the reform-based criteria. This experience may help them see that some classroom teachers do make adaptations to improve the quality of their materials, and in turn, help them recognize that attending to reform recommendations is an important and relevant aspect of teaching practice.
- *Interview focus group of teachers about the reasons why they adapt their curriculum materials.* Teachers modify their materials for a variety of reasons. Some teachers make only context-specific adaptations while others also modify their materials to make them more consistent with reform-based standards and practices. Providing preservice teachers with the opportunity to attend a panel

discussion on the different reasons why teachers modify their curriculum materials may help them learn about the reasons why some classroom teachers attend to reform recommendations in their curricular planning and why other teachers choose to focus on other considerations. This, in turn, may help them see that adapting curriculum materials to make them more consistent with the goals of reform-based science teaching is an authentic aspect of teaching practice, even though not all teachers may make modifications for this reason.

The instructional strategies described above are intended to guide teacher educators as they consider how to support preservice and new teachers' participation with curriculum materials as they develop curricular plans. Even though it may look like there are a lot of instructional recommendations, there are not as many as it may seem because several of the recommendations can relate to facets of the same assignment or set of assignments. For example, several of the instructional strategies relate to observations of classroom teachers around various foci or a progression of lesson plan analyses using different criteria and types of lesson plans. Table 7.2 summarizes the types of course assignments and activities connected to the instructional strategies and shows how these pertain to the instructional goals for science teacher educators as they help beginning teachers develop their beliefs about the design process and a reform-based analytical stance toward science curriculum materials.

Table 7.2

Summary of Main Types of Course Assignments and Activities Connected to Instructional Goals for the Development of Pedagogical Design Capacity

	Course Assignment or Activity			
Instructional Goals	Explorations of reform-based science teaching goals	Series of analysis assignments using criteria	Observations of teachers' curricular planning	Interviews with classroom teachers
Develop pedagogical design capacity for analyzing science curriculum materials.	X	X	X	
Expand beliefs about when & how teachers analyze materials.		X	X	
Expand beliefs about why teachers analyze curriculum materials.	X	X	X	X

Finally, even though the instructional strategies relate to a manageable list of assignments and activities, finding the time to address all of the strategies within these assignments and activities is not likely to be realistic within a single one-semester methods course or a one-year induction program. One way that teacher educators might begin to address some of the recommendations described above is to attend to only one or two strategies within each instructional goal rather than attempt to address all of them at once. They might decide which strategies to apply by determining which strategies they think will be the most beneficial for their particular students, assessing what resources they have available to them, and finding out what experiences their students have already had. Another approach that teacher educators might use as they support preservice and new teachers in developing their pedagogical design capacity is to focus on only two or three reform-based criteria rather than on an exhaustive list of criteria. In deciding what criteria on which to focus, teacher educators might choose criteria that relate to other important goals that they have for their preservice and new teachers in order to address multiple objectives at the same time. Another approach might be to choose two or three criteria that help preservice and new teachers expand their own analysis ideas. For example, focusing on criteria related to ‘assessing student learning’ and ‘making science accessible to all students’ may be fruitful areas of focus for beginning teachers. These suggestions provide insights into some of the ways in which teacher educators might begin to make decisions about how to incorporate some of these recommendations as they address their instructional goals for supporting preservice and new teachers’ participation with curriculum materials.

Implications for the Design of Science Curriculum Materials

In addition to recommendations for science teacher educators, the findings from this dissertation also lead to suggestions for curriculum developers. First, many existing science curriculum materials are of poor quality, failing to focus on key scientific ideas and support students in learning about those ideas (Beyer et al., in press; Forbes, in preparation; Hubisz, 2003; Kesidou & Roseman, 2002; Ochsendorf et al., 2004; Stern & Roseman, 2004). Thus, curriculum writers need to develop improved science curriculum materials that are more consistent with reform-based standards and practices. Providing teachers with high quality materials will enable them to focus less on adapting their materials to improve their overall quality and more on adapting for their specific contextual and personal needs.

In addition to improving science curriculum materials to foster student learning, curriculum developers also need to incorporate curricular features that promote teacher learning. Specifically, curriculum developers need to help teachers, especially beginning teachers, refine their beliefs about curriculum materials analysis. They can do this by including supports that help teachers see that they themselves play a key role in the curriculum materials development process. For example, curriculum materials might include rationales that explain the purpose of particular instructional approaches in order to help teachers understand why curriculum developers included these approaches, and in turn, help them make informed decisions if they choose to make modifications (Beyer & Davis, in press-a; Davis & Krajcik, 2005; Remillard, 2000). Additionally, curriculum materials might include "space" in the materials where parts of lessons are left open-ended in order to provide teachers with the flexibility to make their own decisions (Remillard, 2000, p. 346).

To help teachers develop their beliefs about analysis, curriculum developers can also use curriculum materials to help teachers become aware of the different reasons why teachers modify their materials—for example, for specific students, contexts, teaching styles, and learning goals. Making these ideas explicit to teachers may help them see curriculum materials analysis as an authentic teaching task—that design work does not stop with curriculum writers but continues into the classroom where teachers select and design curricular plans and enact them with students. It may also help teachers experience curricular analysis as a stabilizing experience by emphasizing the idea that it is expected that teachers will modify their materials, even if they have been developed by other individuals and published. Additionally, these educative supports may help teachers expand their beliefs about why teachers analyze curriculum materials.

Finally, in addition to helping teachers modify their beliefs about the role of curriculum materials in their practice, curriculum developers also need to embed supports within written resources to help teachers develop their pedagogical design capacity for analyzing science curriculum materials. For example, curriculum writers might provide instructional guidance that offers teachers suggestions about how they might adapt particular instructional approaches, highlighting potential benefits and limitations of such adaptations (Beyer & Davis, in press-b; Davis & Krajcik, 2005). Such supports may help teachers make thoughtful decisions about how to modify their science curricular resources while maintaining the reform-vision of the materials.

Limitations and Future Research Directions

This dissertation characterized preservice elementary teachers' initial ideas and beliefs about curriculum materials analysis and investigated the use of reform-based criteria to scaffold the development of their pedagogical design capacity for analyzing science curriculum materials. These descriptions shed light on strengths in their ideas and beliefs, areas in need of support, and benefits and limitations of using reform-based criteria as scaffolds. However, it is important to note that the findings and subsequent recommendations from this study are based on only one science methods course. Additional studies situated within other methods courses are needed in order to understand how the findings from this study extend to other preservice teachers and to increase the reliability of the recommendations proposed. Conducting additional studies within different contexts is also likely to lead to the identification of additional struggles preservice teachers face in developing their understanding of reform-based science teaching and applying their understandings in the analysis of science curriculum materials. Additionally, other leverage points and instructional strategies may also be elucidated for supporting preservice teachers in learning about the curriculum materials development process, in general, and the development of science curricular plans, specifically.

Additionally, while this study sheds light on many questions regarding how to support preservice teachers in analyzing curriculum materials, limitations with the supports remained. For example, although the scaffolds helped the preservice teachers learn about how and when teachers engage in design work, the supports largely failed to help them expand their beliefs about why teachers participate in the process of curricular design. Additionally, the scaffolds did not adequately support the preservice teachers in developing their pedagogical design capacity for engaging in authentic analysis tasks, especially during their student teaching semester. Thus, researchers need to investigate additional forms of support, such as those suggested above, in order to illuminate ways in which reform-based criteria might be used more effectively to support preservice teachers' participation with curriculum materials. In particular, this study identified the role of cooperating teachers as an important factor in shaping preservice teachers' opportunities to develop their pedagogical design capacity but did not explore this role in depth. Therefore, more detailed analyses of preservice teachers' field experiences are needed to better understand how these experiences can support them in using reform-based criteria in their design work.

Finally, this study provides in-depth characterizations of preservice teachers' curricular interactions with science curriculum materials during the methods course. However, other questions for future research remain. How do other teacher resources impact preservice teachers' ability to develop an analytical stance toward science curriculum materials and use reform-based criteria? In particular, this study did not investigate the role of preservice teachers' subject matter knowledge in shaping their ability to engage in curricular planning. Because this knowledge domain is likely to be influential in the development of preservice teachers' pedagogical design capacity (Brown, 2009; Remillard, 2005), the field would benefit from future research on this particular teacher resource. Other research questions include, how do preservice teachers use curriculum materials following their participation in a methods course that aims to help them develop beginning level knowledge and skills for analyzing materials, especially during their first year of teaching? Investigating this research question would provide insights into any changes in their beliefs and ideas about curriculum materials analysis after leaving the science methods course and entering the authentic setting of the classroom. Additionally, to what extent are preservice teachers able to apply what they have learned about the design process from analyzing science curriculum materials to other subject areas? Addressing these questions and others will illuminate how teacher educators can support preservice teachers as they engage in curricular design making and provide additional insights into theoretical models on curriculum materials use.

Conclusions

Understanding how preservice teachers critique and adapt curriculum materials is critical to designing teacher education experiences and scaffolds that promote the development of a reform-oriented, analytical stance toward science curriculum materials. Curriculum materials are an essential component of classroom practice, shaping teachers' decisions about what and how to teach. However, many science curricular resources are of poor quality, failing to address key reform-based goals and practices (Beyer et al., in press; Kesidou & Roseman, 2002; Stern & Roseman, 2004). Therefore, it is important that teachers know how to adapt science curriculum materials in order to compensate for these deficiencies. However, little is known about how beginning teachers use science curriculum materials and how they can be supported in developing their pedagogical design capacity for critiquing and adapting them. Research to better understand the participatory relationship between beginning teachers and curriculum materials and the types of scaffolds that can support them in their design work is essential. This dissertation contributes to the literature by suggesting new and important factors for theoretical frameworks on curriculum materials use. It also has important implications for the design of science teacher education, providing evidence for the use of reform-based criteria in supporting preservice and new teachers' participation in the design of the planned curriculum. Thus, this research helps the field conceptualize how beginning teachers analyze science lesson plans, how they can be supported in overcoming the inevitable limitations of curriculum materials, and in turn, how they can use science curriculum materials to provide worthwhile learning experiences for students.

APPENDICES

Appendix A
Pre/Posttests

Lesson Critique Assignment: Keeping the Heat Out

For this assignment, imagine that you are teaching a lesson from a unit on the changes of state in your 4th grade student teaching placement. Imagine that you have taught the first three lessons in the unit and that you are ready to teach the fourth lesson, called *Keeping the Heat Out* (see lesson plan below). In thinking about how you would teach this lesson, complete the following tasks:

1. Describe the strengths and weaknesses of the lesson plan.

2. Modify the lesson plan to address the weaknesses that you identified above. (As you revise the lesson plan, feel free to insert your changes directly into the lesson plan below).

Appendix B
Example of Lesson Plan Analysis Assignment

Lesson Plan Analysis Assignment <#>: <Lesson Title>

Teachers modify lessons to better meet their own teaching style and the needs of their students. Applying criteria in your analysis of lesson plans can help you think about how you can make productive changes to lessons you find – a major focus of this course. The purpose of this assignment is to help you (a) think about how you can use criteria to identify strengths and weaknesses in a lesson plan and (b) begin to think about how you can make changes to lessons in order to foster inquiry and attend to kids' ideas.

Teachers possess ideas about effective science teaching and they use those ideas to determine whether curriculum materials have those characteristics or not. To do a good job at analyzing curriculum materials, you too need to have some criteria by which you can judge the materials. In this assignment, you will have the opportunity to practice analyzing a lesson plan with regard to 3 criteria that you've recently learned about in class. These criteria focus on key aspects of effective science teaching.

In class, you've also identified important characteristics of these 3 criteria. These characteristics will help you judge how well the lesson plan meets each criterion. Below are the 3 criteria (numbered) and their characteristics (lettered) that you will use in this analysis:

<<1. Attending to learning goals
   A. Do the learning goals address both science content and inquiry?
   B. Are the learning goals grade-appropriate & aligned with standards documents?
   C. Are the learning goals aligned with activities?

2. Establishing a sense of purpose
   A. Does the lesson help teachers make the purpose of the activity explicit to students?
   B. Is the purpose meaningful to students and anchored in the lives of learners?
   C. Does the lesson help the teacher connect the purpose of the activity to what students have been learning about thus far in class?

3. Eliciting students' ideas at the beginning of a lesson
   A. At the beginning of the lesson, does the lesson enable the teacher to elicit students' ideas about the new content <u>and</u> predictions about the phenomena?
   B. Does the lesson ask students to give explanations for their ideas <u>and</u> predictions in order to help teachers probe beneath students' responses?
   C. Does the lesson provide opportunities for students' ideas <u>and</u> predictions to be recorded and shared with others in the class?>>

In your CASES journal, analyze the lesson plan with regard to each criterion by responding to the questions above. As you respond to each question, make sure to include the following things:

- Decide whether the lesson plan meets or does not meet the indicator. Explain why you think this and provide examples from the lesson plan to support your ideas.
- For the weaknesses that you identify, describe specific changes you could make to improve the lesson plan.

Appendix C
Example of Analysis Task and Lesson Plan Description in Reflective Teaching Assignment

Reflective Teaching Assignment [#1]

Part 1a: Lesson Plan Analysis Task

Teachers possess ideas about effective science teaching and they use those ideas to determine whether curriculum materials have those characteristics. To do a good job at analyzing curriculum materials, you need to have some criteria by which you can judge the materials. In this part of the assignment, you will analyze your lesson plan with regard to **3 criteria of your own choosing**. You can select criteria that you've recently learned about in class or select your own criteria.

Use the following questions to guide your description and use of the criteria in your analysis.

For each criterion, answer the following questions:

1. What criterion did you choose?
2. Why did you choose to use this criterion in your analysis?
3. What are the indicators for this criterion? (Identifying indicators will help you identify important characteristics of the criterion that you can use to guide your analysis.)
4. For each indicator: Does the lesson plan meet the indicator? Explain why you think this and provide examples from the lesson plan to support your ideas. For the weaknesses you identify, what specific changes could you make to the lesson to better meet the indicator?

Remember to address these four questions for each of the three criteria.

Criterion #1

Criterion #2

Criterion #3

Part 1b: Revised Lesson Plan

Title of Lesson:

Grade level:

Length of lesson:

Overview:

- Provide a short description of the lesson:

Learning Goals:

Criterion 1a

- What do you want students to know and be able to explain at the end of this lesson?
- What do you want students to be able to do (with regard to inquiry)?

Connections to Standards/ Benchmarks/ Curriculum:

Criterion 1b

List the standards as written in the *Michigan Curriculum Framework* (or the *Science Grade Level Content Expectations* document, which clarifies the MCF), *National Science Education Standards*, or AAAS *Benchmarks*. Write down what chapter, section, and grade level you drew the standard from, in addition to the source itself.

Context of Lesson:

How does the lesson fit within the unit as a whole?

Materials:

Students' Ideas:

- What ideas should students understand before beginning the lesson?
- What potential alternative ideas might students hold?

Teaching Strategies: Intro

Think about the following questions as you describe how you will introduce the lesson:

- How will you connect this lesson to the previous one?
- What is your investigation question or problem for the lesson?
- How will you elicit students' existing ideas?

Criterion 2c
Criterion 2a
Criterion 3a

Teaching Strategies: Main Lesson

Think about the following questions as you describe the steps of the lesson:

- What will you do? What will your students do? Do not assume someone reading your lesson plan has access to the original lesson plan! Be clear and complete.
- Do the activities support students in engaging in scientific inquiry? How will you help students make predictions? Collect data and make observations? Look for patterns in data? Build evidence-based explanations?
- What will you do to manage materials/movement around the classroom/transitions?
- Do the activities support students of all achievement levels? What will students do who finish an activity early? Who do not finish?

Criterion 3a
Criterion 4bc
Criterion 5a

Criterion 7a

Teaching Strategies: Wrap-up

Think about the following questions as you describe how you will close the lesson:

- What explanations will your students construct?
- How will you help students connect their explanations to the investigation question?
- What specific questions will you ask students to help them interpret their in-class experiences and connect them to scientific ideas and their own ideas about the phenomena? What questions will you ask to help students progress from their initial ideas and predictions elicited at the beginning of the lesson?
- How will you help students connect to previous and subsequent science lessons?

Criterion 5a

Criterion 5b
Criterion 5c

Assessment:

- What evidence will you gather to let you know if your students achieved the learning goal(s)? How will you collect this information?
- Does your assessment focus on understanding of key ideas and practices and require application of ideas?
- Are you able to assess each student's understanding?

Criterion 6a
Criterion 6c
Criterion 6b

Appendix D

Curriculum Materials Use Assignment

Teachers often make modifications to lessons before actually teaching them in order to better meet their own teaching style and the needs of their students. The purpose of this assignment is to provide you with an opportunity to get a glimpse into your cooperating teacher's practice to examine in what ways your teacher modifies lesson plans and for what reasons.

Description of Assignment

1. Explain to your cooperating teacher that your science methods class is helping you learn how to analyze the strengths and weaknesses of lesson plans and how to change them in order to better meet your own teaching style and the needs of your students. Also explain that you have been given an assignment to better understand the ways in which your cooperating teacher plans for lessons and the things that s/he considers when deciding how to use a lesson plan for instruction.

2. Ask your cooperating teacher for a copy of a lesson plan that they will be teaching in your field placement this week. (This lesson should ideally be from science but can be taken from any subject.) Explain to your cooperating teacher that you will be reading through the lesson plan and then observing how the lesson is actually taught in class. Ask your cooperating teacher if s/he will have ten minutes to talk with you sometime after the lesson about your observations and other questions you might have.

3. Observe the enactment of the lesson. Note any interesting changes or additions you see that your cooperating teacher has made to the lesson. (This is a great opportunity to ask your field instructor to co-observe with you.)

4. Following the lesson, talk with your cooperating teacher about the following questions and any other questions you might have. (Use these questions as an opportunity to learn about your cooperating teacher's practice, and be respectful of the answers s/he gives and the ideas s/he shares with you.)
   - Have you taught this lesson before or was this your first time teaching this lesson?
   - How did you plan for this lesson? Did you make any changes to the lesson before teaching it? If so, why did you make these changes?
   - How often do you make changes to lesson plans as you plan for instruction?
   - Do you modify lesson plans to different extents depending on the subject matter? If so, what do you think causes the variation?
   - What are some reasons you make changes to lesson plans before teaching them?

5. Finally, write a journal entry describing what you have learned from this experience. In particular, address as many of the questions in #4 as you can in your summary statement. Post your assignment in the CASES journal space.

Appendix E

Relevant Excerpts from Questionnaire

Practicum placement district, school, and grade:

Major:

Minor:

Do you anticipate obtaining a teaching position when you graduate?

- o Yes
- o No

Science courses you’ve taken or will taken this semester (high school and college; names or subjects are fine):

How do you feel about teaching science?

- o Very nervous
- o Somewhat nervous
- o OK
- o Pretty confident
- o Very confident

Which of the following statements apply to how you feel about science and teaching science?

- o I feel confident in my understandings of science.
- o I have not done very well in my science courses

Word that best describes how you feel about science?

Word that best describes how you feel about science teaching?

Appendix F
Interview Protocols

Their ideas about what it means to be an effective science teacher

Interview	Question	RQ
1,2,3	To begin, I'd like for you to pretend that a principal is considering you as a candidate for a teaching position where teaching science and working with science curriculum materials will be important. The principal is interviewing you for the position and would like to know what you think are some of the important characteristics of effective elementary science teaching. What important characteristics would you talk about?	2c
	Probe: Why do you think this characteristic is important?	
1,2,3	The principal also places a strong emphasis on working with curriculum materials in science. How do you think an effective elementary teacher should use science curriculum materials?	3a
	Probe: Why do you think this is important?	
1,2,3	What specific experiences do you think have shaped your ideas about effective science teaching? About the role of curriculum materials in elementary science teaching?	2c, 3a
	Probe for Interview 2 only: Were there any experiences (e.g., readings, discussions, assignments) from the science methods course that influenced your thinking?	

Debrief Pre/Posttest

Interview	Question	RQ
1,2	How did you go about completing the [first/second] lesson critique assignment for your science methods course?	2a
	Probe: The assignment asked you to identify strengths and weaknesses in the lesson plan. How did you go about identifying these strengths and weaknesses?	
1,2	Some people analyze lesson plans by reading through a lesson plan and seeing what jumps out to them as important strengths and weaknesses. Other people have a couple things (or criteria) that they think are important to look for before they begin their analysis and then use those criteria to guide their analysis. Would you say you evaluated your lesson plan in either of these two ways? Please explain. If not, how would you say you evaluated the lesson plan?	2a

1,2	What were the most important things that you considered in your analysis? Why did you think these things were important? *Probe for Interview 2 only*: In your science methods course, you learned about several criteria for critiquing and adapting curriculum materials. Did you think about any of those criteria as you completed the assignment? Which ones? Why did you think about this criterion?	2b, 2c
2	What big changes do you see in how you analyzed this lesson at the beginning of the semester with how you analyzed the lesson at the end of the semester? Why do you think your ideas have changed? *(Note to self: Do they perceive a change toward a criterion-based approach to analysis? Using the criteria learned in class?)*	2a, 2b, 2c

Debrief their curricular planning experiences during their student teaching semester

Interview	Question	RQ
3	Did you have the chance to teach science this semester? *If yes, probe:* • How many science lessons did you teach? • What science topics did you teach?	2a, 2c
3	How did you plan for the science lessons that you taught? • Did you critique and adapt your lesson plan as you planned?	2a
3	What ideas did you think about and consider as you planned for your science lessons? *Probe:* • Why do you think this is important? • Did you think about any of the criteria that you learned about in the science methods course as you planned for your lesson?	2b, 2c
3	Did you explicitly think about criteria when you planned for your science lesson? Why or why not?	2a

Views on the usefulness and authenticity of curriculum materials analysis

Interview	Question	RQ
2,3	How often did you see science taught in your field placement? *(Probe for frequency during each week and across the semester.)*	3a
1,2,3	How often have you seen your current cooperating teacher (or previous cooperating teachers) critique and adapt curriculum materials (in general)? In what subject matter areas? In science?	3a
1,2,3	To what extent do you think teachers actually critique and adapt curriculum materials as a part of their daily work as teachers? Why do you think teachers critique and adapt their lessons when they plan for instruction?	3a

1,2,3	*If there is a difference between what they saw and what they think teachers actually do, ask:* So it sounds like you think that classroom teachers actually critique and adapt curriculum materials as part of their practice. If that is the case, why do you think you have not observed your cooperating teacher critique and adapt curriculum materials very often in your field placement?	3a

Views on the usefulness and authenticity of applying criteria in analyzing lesson plans

Interview	Question	RQ
2	In your reflective teaching assignment, you analyzed your lesson plan (using your own criteria; using some of the reform-based criteria as well as some of your own criteria; using the reform-based criteria). Why did you decide to use (your own criteria rather than the reform-based criteria; a mix of both your own criteria and reform-based criteria; the reform-based criteria rather than your own criteria)?	1b
1,2,3	Card-Sorting Task: I'd like for you to examine a list of analysis criteria and sort them into one of three categories based on your opinion about what criteria you think are very important, somewhat important, or not important for you to think about as you analyze lesson plans. *Probes*: • After preservice teacher sorts the cards, ask her to explain why she placed particular criteria in certain categories. • If she places several criteria in the 'very important' category, ask her to choose three of those criteria that she thinks are the main criteria she will focus on in the near future.	2d
2,3	How useful do you think it is to think about criteria when critiquing and adapting lesson plans? Why do you think this?	3a
2,3	To what extent do you think classroom teachers think about particular criteria (whether explicitly or implicitly) when they critique and adapt science lessons? *Probe if yes:* • Why do you think they use criteria when they plan for instruction? • What criteria do you think they consider in their analyses? • Do you think they consider the criteria that you learned about in class? If so, which ones?	3a
2,3	Some people think it is pointless to learn about criteria for analyzing science lesson plans because the adaptations that teachers make will always be specific to their students' needs and teaching style while other people think that there are some criteria that are beneficial for all teachers to consider in order to improve the quality of their science curriculum materials. What do you think about this and why?	3a

Comfort level with curriculum materials analysis and factors impacting comfort level

Interview	Question	RQ
1,2	How would you describe your comfort level with regard to critiquing and adapting science curriculum materials? Why do you feel this way?	3b
1,2	On a scale of 1 to 5, how would you rate your comfort level with critiquing and adapting science curriculum materials at the (beginning/end) of the semester? (1 = very uncomfortable; 5 = very comfortable)	3b
1,2	What factors do you think have influenced your comfort level (or the change in your comfort level)? *Probe:* Do you feel like your…has influenced your comfort level with regard to critiquing and adapting science curriculum materials? Explain. • *Level of understanding of science* • *Level of understanding about how to critique science curricula* • *Level of understanding about how to adapt science curricula* • *Views on whether it is appropriate for teachers to critique and adapt curriculum materials*	3b
1,2	To what extent do you feel that *high quality* curriculum materials need to be critiqued and adapted? Why do you think this?	3b
1,2	When asked to critique and adapt curriculum materials, do you feel like you are being asked to question the knowledge and authority of the (curriculum developers/cooperating teacher/future classroom teachers at the school where you will be teaching)? Why do you think you feel this way?	3b

Thinking about being an elementary science teacher

Interview	Question	RQ
1,2,3	I'd now like for you to imagine that you are in your first year of teaching as an elementary school teacher and to think about how you see yourself teaching science. As you think about your future science instruction, describe what a typical science lesson might look like in your classroom. *Probes*: What would you do first? What would happen next? How would you end of the lesson?	2b, 2c
1,2,3	How do you think you will use curriculum materials in teaching	3a

	science?	
	Probe: Do you think you will be critiquing and adapting lesson plans?	
1,2,3	Let's say you are preparing to teach the next lesson in your science unit. As you read through the lesson plan, what important things will you consider as you plan for your lesson? Why do you think these things are important?	2b, 2c

Do you have any final comments, questions, or other things you'd like to tell me?

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