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Developing Preservice Elementary Teachers' Pedagogical Design Capacity for Reform-Based Curriculum Design

CARRIE J. BEYER
& ELIZABETH A. DAVIS

University of Michigan
Ann Arbor, Michigan, USA

ABSTRACT

Teachers use curriculum materials as a guide in their planning, critiquing and adapting them to address reform-based goals and practices and specific contextual needs. To become well-started beginners in planning lessons, novice teachers need opportunities to develop their pedagogical design capacity—that is, their ability to use personal and curricular resources in designing instruction for students. This study investigated the use of reform-based criteria in supporting 24 preservice teachers enrolled in an elementary science methods course. In learning about and applying criteria, the preservice teachers developed aspects of their pedagogical design capacity by expanding their analysis ideas and refining their knowledge and beliefs about curriculum design. However, many struggled with analyzing lesson plans in a reform-oriented way during student teaching. This occurred, in part, because the preservice teachers navigated different settings that conveyed conflicting ideas about the reasons why teachers make modifications. The methods course emphasized the importance of modifying materials to promote reform-based science teaching, but few preservice teachers observed their mentor 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.

INTRODUCTION

In their daily work teachers engage in the process of curriculum design, drawing upon personal characteristics, curricular features, and contextual resources in creating instructional plans and enacting those plans with students (Ben-Peretz, 1990; Brown, 2009; Clandinin & Connelly, 1992; Remillard, 2005). As part of this design work, teachers critique curriculum materials—assessing their strengths and weaknesses—and make adaptations. We use the term *analysis* to refer to both practices.

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Even though curriculum design is an essential aspect of teaching practice, novice teachers encounter many difficulties (Davis, 2006; Grossman & Thompson, 2008; Nicol & Crespo, 2006; Schwarz et al., 2008; Valencia, Place, Martin, & Grossman, 2006). Teachers who do not know how to analyze curriculum materials in productive ways may make counterproductive changes or fail to make much-needed modifications to lessons. To prepare novice teachers in becoming well-started beginners in analyzing curriculum materials, teacher educators play a pivotal role in helping novices learn how to use curriculum materials in ways that best promote student learning while meeting the personal needs of both teachers and students.

Unfortunately, few studies have examined how novice teachers think about and engage in curriculum design and how teacher educators can support them in doing so. This is especially true for preservice *elementary* teachers' use of *science* curriculum materials in the participation of *reform-based* curriculum design (Beyer & Davis, 2009; Davis, 2006; Forbes & Davis, 2010; Schwarz et al., 2008). This study addresses this gap by examining the use of research-based, analysis criteria in helping preservice elementary teachers develop a reform-based, analytical stance toward curriculum materials.

THEORETICAL FRAMEWORK

Curriculum Materials Analysis

Teachers engage in the process of curriculum design in their planning, teaching, and reflection on practice. Within each of these phases of instruction, teachers make both large- and small-scale adaptations to curriculum materials (Drake & Sherin, 2006; Sherin & Drake, 2009). At the unit level, teachers create new lessons, substitute one lesson for another, or omit lessons altogether. They also make changes within lesson plans themselves, for example, by adapting activity sequences, materials used, participant structures, and time allocated.

When teachers engage in curriculum design, particular considerations often guide their analysis. First, curriculum materials are typically designed for a general audience and broad context. Thus, teachers make adaptations based on their specific students' needs, contextual circumstances, and local goals and standards (Brown, 2009; Pintó, 2004; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). Second, curriculum materials differ in their consistency with reform-based practices, particularly in science (Beyer, Delgado, Davis, & Krajcik, 2009; Kesidou & Roseman, 2002; Stern & Roseman, 2004). Curriculum materials grounded in reform-based practices are informed by current research on how best to promote student learning and thus are intended to provide high-quality instructional support for all

students. Thus, teachers also make modifications based on reform-based practices. This type of modification is the focus of this study.

Teacher–Curriculum Materials Participatory Relationship

Teachers and curriculum materials participate together in the design of the planned and enacted curriculum (Brown, 2009; Remillard, 2005). On the one hand, curriculum materials contain content for students to learn and activities for learning about those ideas. Underlying these components, curriculum materials also contain historical, social, and cultural values that specify (often implicitly) what subject matter is important to teach and how to teach it (Wertsch, 1991). These *material resources* influence how teachers read and interpret lesson plans and ultimately how they use them in practice. On the other hand, teachers bring an array of experiences, dispositions, beliefs, knowledge, and abilities (Pintó, 2004; Remillard, 1999; Squire et al., 2003). These *personal resources* help teachers make sense of the offerings provided in curriculum materials and decide how to use them in practice.

In the participatory relationship, teachers and curriculum materials are also in dynamic interaction with classroom and school contexts (Remillard, 2005). Students have a unique set of ideas, experiences, and resources, shaping teachers' pedagogical decisions (Sherin & Drake, 2009). Policy guidelines, local curriculum frameworks, parental views, and departmental expectations also impact teachers' perceptions of the level of flexibility they have in design work (Pintó, 2004; Remillard, 1999; Squire et al., 2003). These interactions among teacher, curriculum materials, and context result in unique patterns of curriculum materials use and thus differential opportunities for student learning.

In her framework conceptualizing the teacher–curriculum materials relationship, Remillard (2005) described a variety of personal resources that teachers draw upon in their curriculum design work. One resource of particular interest in this study is teachers' pedagogical design capacity (Brown, 2009). This capacity entails teachers' ability to identify and draw upon their own personal resources, in addition to the resources within curriculum materials, in designing powerful learning experiences for students. Teachers act upon these resources by negotiating the affordances and constraints of particular curricular features while taking into consideration their own understandings, goals, and classroom needs. In these ways, teachers' capacity for pedagogical design shapes the ways in which they interpret and critique curriculum materials and ultimately how they use and adapt them in practice.

Challenges to Developing Novice Teachers' Pedagogical Design Capacity

Even though teachers' pedagogical design capacity plays an important role in mediating their interactions with curriculum materials, many novice

teachers face challenges with developing this capacity. Some novices are uncritical users of curriculum materials, relying heavily upon them to determine what and how to teach (Ball & Feiman-Nemser, 1988; Bullough, 1992; Grossman & Thompson, 2008; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Schwarz et al., 2008; Valencia et al., 2006). This occurs, in part, because some novices do not have the knowledge and skills to engage in design work. Others see curriculum developers as more knowledgeable than themselves, leading them to view curriculum design as a destabilizing experience. Still other novices do not perceive practicing teachers as flexible users of curriculum materials, leading them to view curriculum design as an inauthentic teaching task.

Other novices critique and adapt curriculum materials but also encounter challenges. Some make adaptations that are limited in scope, largely focused on the practical and affective aspects of teaching, such as providing clear directions or making activities fun (Lloyd & Behm, 2005; Nicol & Crespo, 2006; Schwarz et al., 2008). Others inadvertently distort the intent of the original materials—omitting or changing parts of lessons essential for student learning (Ball & Feiman-Nemser, 1988; Pintó, 2004; Squire et al., 2003). For these reasons, teacher educators need to help beginning teachers develop their pedagogical design capacity, preparing them to be principled, analytical users of curriculum materials.

Purpose of the Study and Research Questions

To address this need, we conducted research with 24 preservice elementary teachers enrolled in a science methods course intended to develop their pedagogical design capacity. The construct of "pedagogical design capacity" is a relatively new idea in the research literature with many different dimensions yet to uncover and explore (Brown, 2009). This study investigated one specific aspect of this construct—teachers' pedagogical design capacity for reform-based curriculum design. We defined this construct as teachers' ability to act upon a range of resources to design and enact instruction aligned with reform-based standards and practices. We explored this dimension within a particular set of parameters. We investigated novice teachers' capacity to engage in design work during the planning phase of instruction. We focused on their use of individual lesson plans drawn from existing curriculum materials (rather than on their ability to craft instruction using no curricular resources or a variety of resources). Additionally, we focused on characterizing the analysis ideas that the novice teachers expressed in their critique and adaptation of curriculum materials. We defined "analysis ideas" as the implicit or explicit criteria upon which teachers draw in assessing the strengths and weaknesses of an existing lesson plan and deciding how to adapt it for instruction.

In this study we also examined the role of two personal resources in supporting or constraining teachers' pedagogical design capacity. Research

studies have found that teachers act upon a wide variety of knowledge and beliefs in crafting instruction for students, including ideas about the subject matter, teaching, and learning (e.g., Collopy, 2003; Pintó, 2004; Remillard, 1999; Squire et al., 2003) as well as beliefs about the curriculum materials themselves (Remillard & Bryans, 2004). This study explored another dimension of this personal resource—teachers' knowledge and beliefs about curriculum materials analysis. This set of knowledge and beliefs includes teachers' perspectives on whether critiquing and adapting curriculum materials are authentic teaching practices, and if so, when, how, and why teachers engage in this design work. Other research has shown that teachers also draw upon their professional identity in their collaboration with curriculum materials (e.g., Collopy, 2003; Drake & Sherin, 2006; Forbes & Davis, 2008; Frykholm, 2004). This study examined one aspect of this personal resource—teachers' confidence level with engaging in curriculum design. This construct focuses on teachers' perceptions of their ability to critique and adapt curriculum materials to achieve productive instructional ends.

Toward these goals, the methods course emphasized the use of a set of reform-based criteria in mediating preservice teachers' interaction with curriculum materials. These criteria, representing research-based ideas about effective science teaching (Kesidou & Roseman, 2002; Stern & Roseman, 2004), provided preservice teachers with analysis ideas for improving the quality of instructional support within curriculum materials. The preservice teachers also investigated their mentor teachers' planning practices, formally, in an assignment, and informally, in their field observations.

Through these experiences, we aimed to develop preservice teachers' pedagogical design capacity for reform-based curriculum design. Specifically, we hoped the preservice teachers would gain an understanding of the different aspects of reform-based science teaching and the importance of analyzing curriculum materials in a reform-based manner to promote effective science teaching. Additionally, in their curricular planning, we hoped the preservice teachers would expand their analysis ideas to include the reform-based criteria and use these criteria to identify strengths and limitations within curriculum materials and make appropriate modifications.

As the preservice teachers developed their pedagogical design capacity, we also aimed to develop their professional identity—specifically, to increase their confidence level with engaging in curriculum design. Finally, we hoped the preservice teachers would develop their knowledge and beliefs about curriculum materials analysis. This included helping the preservice teachers see that critiquing and adapting are authentic teaching practices and that teachers engage in these design tasks during all phases of instruction, make both small- and large-scale changes to curriculum materials, and adapt lessons for a variety of reasons, including for reform-based standards and practices.

In this study we asked the following research questions:

(1) *When preservice elementary teachers critique and adapt science lesson plans, what are their analysis ideas and how do they change over time?*
(2) *What are preservice elementary teachers' knowledge and beliefs about curriculum materials analysis and what experiences do they identify as shaping their knowledge and beliefs?*
(3) *What is preservice elementary teachers' confidence level with engaging in curriculum design, and what factors do they attribute to their perceptions?*

This study provides insights into theoretical perspectives on curriculum materials use. It also has implications for the design of teacher preparation and induction programs in supporting novice teachers in using curriculum materials for effective science teaching.

METHODS

Research Setting and Participants

This study focused on an elementary science methods course at a large Midwestern university in the United States. This course was situated within the third semester of a 2-year undergraduate teacher preparation program. Preservice teachers entered the program during their third year of college. They completed university courses and field work in elementary schools during the first three semesters and their student teaching during the final semester.

Twenty-four (of 28) preservice teachers consented to participate in the study. We used pseudonyms to maintain confidentiality. The participants were mainly traditional fourth-year college students and similar to elementary teachers in the United States—primarily white and female (NCES, 2007). A subset of the preservice teachers also participated in interviews. We selected a group of seven interviewees representing a range of teaching majors (1 science, 2 social studies, 2 language arts, 2 math) and field placements drawn from five school districts.

The Role of the Researchers

The first author served as the instructor for one section of the science methods course, and the second author served as the lead faculty member. As instructor, the first author co-planned and led 13 three-hour class sessions. Both authors served as researchers for the study. At the beginning of the course, the first author obtained consent to use coursework for research purposes and interview a subset of the preservice teachers. The interviews took place at the beginning and end of the course. Aside from obtaining consent, the first author did not assume the role of

researcher during the class sessions themselves, allowing her to focus on her role as instructor. While the study bears some similarity to self-study in teacher education (e.g., Dinkelman, 2003), it largely draws on design-based research (e.g., Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003) as the authors/instructors were primarily interested in better understanding the preservice teachers' ideas and practices around curriculum materials analysis.

The first author interviewed her own students, which allowed her to establish a sense of rapport that might not have otherwise been possible with an unknown researcher. On the other hand, because the interviewer also served as their course instructor, the interviewees might have expressed limited trust and openness. We aimed to address this issue in two ways. First, the first author helped the interviewees see that the interviews benefited them by providing opportunities to reflect upon their science teaching and allowed them to provide feedback for improving the course. Second, the first author conducted the interviews outside the span of the course in order to help the interviewees feel like they could honestly express their views without fearing that the interviews would influence their grades. In the collected data (described in the Results section below), some of the interviewees expressed knowledge and beliefs contrary to the course itself, suggesting that the interviewees felt like they could be open and honest during the interviews.

Instructional Context

The science methods course focused on inquiry-oriented science teaching, students' ideas about science, and the adaptation of science curriculum materials (Davis & Smithey, 2009). This research study addressed all three course goals, with the third goal serving as the main focus. The course aimed to help preservice teachers develop their pedagogical design capacity for reform-based curriculum design by introducing them to a set of reform-based criteria for analyzing science lessons. Like others (Schwarz et al., 2008), we based these criteria on a modified version of the American Association for the Advancement of Science (AAAS) Project 2061 Instructional Analysis Criteria (Kesidou & Roseman, 2002; Stern & Roseman, 2004). Project 2061 criteria are informed by research on student learning and contain ideas related to instructional effectiveness consistent with reform-based standards and practices. The criteria in this study included (1) attending to learning goals, (2) establishing a purpose, (3) eliciting students' prior knowledge and predictions, (4) providing experiences with phenomena, (5) promoting students' sense making, (6) assessing student learning, and (7) making science accessible for all students. See Beyer and Davis (2012) for additional information.

At the start of the course, the preservice teachers analyzed a science lesson plan (without guidance) as part of a pretest. The preservice teachers

then used their analysis ideas from the pretest to generate an initial class list of ideas for analyzing science lessons. Subsequent class sessions were devoted to learning about the reform-based criteria. In each class, the preservice teachers developed their understanding of a new criterion through activities and discussions and made connections to the initial class list of analysis ideas, as relevant. At the end of class, the preservice teachers recorded their ideas on exit slips about how they might apply the criterion in analyzing science curriculum materials. In later class periods the instructor introduced a list of indicators (framed as questions) to use when applying the newly learned criterion in analysis work and made explicit connections between the ideas in the exit slips and these indicators. The preservice teachers then completed lesson plan analysis assignments, allowing them to practice applying the criteria they had learned about in class. These assignments entailed identifying aspects of the lesson plan that met or did not meet each criterion, justifying these ideas, and describing adaptations to improve the lesson.

Because preservice teachers do not necessarily see curriculum design as authentic or relevant to practice (Nicol & Crespo, 2006; Schwarz et al., 2008), this study provided the preservice teachers with two additional learning experiences. First, the preservice teachers investigated their mentor teachers' planning practices by making observations of their lesson planning and engaging in structured conversations with their mentor teachers about how they plan for instruction. Second, the preservice teachers participated in two authentic analysis experiences, where they obtained lessons from their mentor teacher, analyzed the lessons using criteria, and modified and taught these lessons in their field placements. These experiences enabled the preservice teachers to develop their ideas about the authenticity of curriculum design and apply what they had learned about the criteria to their own teaching practice.

Study Methods

Data Sources

Pre-/Posttests. The preservice teachers completed a pretest and posttest at the beginning and end of the course. The pre-/posttests served as course assignments as well as data for the study. In each, they analyzed the same lesson plan, which had fourth and fifth graders explore the concept of melting by designing a container to keep an ice cube frozen for as long as possible. We used the same lesson plan for both assignments so the preservice teachers would be able to directly compare their analysis ideas from pre to post. Using the same lesson also had affordances for the research design. Lesson plans vary in terms of the number and kind of strengths and weaknesses they have, and in turn, the degree of difficulty entailed in making appropriate modifications to improve them. Therefore,

we decided to provide the preservice teachers with the same lesson plan from pre to post to provide them with lesson plans that had parallel strengths and weaknesses and similar degrees of challenge in compensating for their deficiencies.

The pre-/posttests asked the preservice teachers to describe the strengths and weaknesses of the lesson and modify it to address its weaknesses. At the beginning of the course, the preservice teachers used the pretests as a springboard for brainstorming, as a class, a general list of ideas for analyzing lesson plans. They did not discuss the specifics of their pretest responses with others in the class; they also did not receive feedback or grades on this assignment from the instructor. At the end of the course, the preservice teachers compared their pre-/posttest responses to identify similarities and differences in their analysis ideas. Like the pretests, the posttests were ungraded. As a data source, we used the pre-/posttests to describe the preservice teachers' analysis ideas and any changes in these ideas after experiencing the science methods course.

Curriculum materials use assignment. At the start of the course, the preservice teachers completed the curriculum materials use assignment as ungraded coursework, where they read a lesson plan from their mentor teacher, observed its enactment, and reflected upon the lesson with their mentor teacher. The preservice teachers received a list of questions to guide their discussion about how their mentor teacher planned for the lesson and plans for instruction, more generally. The preservice teachers then completed a written response where they reflected upon these questions and the mentor teachers' responses. We used this data source to describe the preservice teachers' knowledge and beliefs about the authenticity of curriculum materials analysis and factors impacting these knowledge and beliefs.

Interviews. We interviewed seven preservice teachers three times during the study, once at the beginning and end of the course and once at the end of student teaching. Interviews were audio-recorded and transcribed and were approximately 45–60 minutes in length. These interviews elicited the preservice teachers' knowledge and beliefs on the role of curriculum materials in elementary science teaching, including how classroom teachers use curriculum materials in planning and how they see themselves using science curriculum materials during their first year of teaching. Additionally, in the first and second interviews, the preservice teachers described the analysis ideas they used in the pre-/posttests and their confidence level with analyzing curriculum materials. During the second and third interviews, the interviewees shared their views on the authenticity of applying criteria in analyzing lesson plans. Finally, in the third interview the preservice teachers described their curricular planning experiences during student teaching.

We used this data source to describe the preservice teachers' analysis ideas during the course and student teaching. The interviews also provided

insight into their knowledge and beliefs on the authenticity of curriculum materials analysis, a criterion-based approach to analysis, and the use of reform-based criteria to analyze lesson plans. Additionally, these interviews uncovered the preservice teachers' confidence level with curriculum design and the affordances and constraints impacting their perceptions. Finally, conducting the interviews at three different points shed light on how the preservice teachers' beliefs and perceptions changed over time.

Data Coding and Analysis

Analysis ideas. We coded for the types of analysis ideas that the preservice teachers used or mentioned in the pre-/posttests and interview transcripts (see Table 1). We assigned one code to each strength or weakness that the preservice teacher identified. We derived the initial coding key from the reform-based criteria and iteratively revised it to account for the preservice teachers' own intuitive criteria for analysis. We added ideas to the coding scheme if at least one-fourth of the preservice teachers expressed them in either the pre- or posttest. After coding the data, we calculated the frequency of analysis ideas related to the reform-based criteria and their own intuitive criteria and conducted two-tailed paired samples *t*-tests in order to compare their use of these two types of 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, we also identified patterns in the types of analysis ideas that the preservice teachers mentioned in each interview and any changes in these ideas across the course and student teaching semester.

Knowledge and beliefs about curriculum materials analysis. We analyzed the interview transcripts for preservice teachers' knowledge and beliefs about curriculum design. We used open coding strategies by iteratively reading the transcripts and adding comments to sentences or paragraphs related to preservice teachers' ideas about curriculum design and experiences accounting for their knowledge and beliefs (Strauss & Corbin, 1998). For example, we noted the preservice teachers' perceptions about when and how teachers use curriculum materials in their practice and why teachers use curriculum materials in particular ways. We then identified codes and subcodes from these descriptive comments (see Table 2). Next we ascertained themes for each code by identifying common subcodes or groups of subcodes among the preservice teachers. We examined how these themes changed during the methods course and student teaching semester. These themes shed light on the preservice teachers' evolving knowledge and beliefs about the authenticity of curricular analysis, including when, how, and why teachers use curriculum materials.

We also analyzed the curriculum materials use assignment to triangulate with findings from the interview data. We used the same coding scheme from the interviews to code the assignments (see Table 2) and subsequently identified themes by uncovering common subcodes among the preservice

TABLE 1
Coding Scheme for Type of Analysis Ideas Expressed by Preservice Teachers

Code	Description
Analysis Ideas Related to Reform-Based Criteria	
Learning goals	Inquiry and content learning goals are addressed and aligned with standards and lesson activities.
Lesson purpose	Purpose is explicit and relevant to students.
Students' ideas	Lesson provides strategies for eliciting and interpreting students' prior knowledge and predictions.
Phenomena	Lesson provides experiences with phenomena and opportunities to collect and analyze data.
Sense making	Lesson includes strategies for guiding student interpretation and opportunities to develop explanations.
Assessment	Lesson assesses each student's understanding and skills and has them apply their ideas to new tasks.
Accessible science	Lesson introduces terminology in meaningful ways and helps students make personal connections to science concepts.
Other Analysis Ideas	
Fun and engagement	Lesson engages students and makes science fun and interesting.
Clarity and feasibility	Lesson has clear, feasible information on procedures.
Hands-on activities	Lesson provides students with hands-on experiences.
Classroom management	Lesson provides guidance on how to manage student behavior.
Explanations and definitions	Lesson includes explanations of phenomena and definitions of terms for students.
Cooperative learning	Lesson supports student learning through group work.
Student directedness	Lesson enables students to design their own investigations.

teachers. These themes shed light on the preservice teachers' perceptions on when and how their *mentor teachers* used curriculum materials in their practice and why they engaged (or did not engage) in the task of curriculum design.

Confidence level with curriculum design. We coded the interviews for preservice teachers' self-reported confidence level with critiquing and adapting science curriculum materials and their perception of factors impacting their confidence level, including their science subject matter knowledge, knowledge of science teaching, and the knowledge and author-

TABLE 2
Emergent Codes and Subcodes for Knowledge and Beliefs About Curriculum Materials Analysis

Codes	Subcodes
Authenticity of curriculum materials analysis	Authentic part of teaching practice
	Inauthentic part of teaching practice
Why teachers analyze curriculum materials	For specific students (e.g., their needs, abilities, interests, behavior)
	For their own teaching style
	For local standards
	For specific context (e.g., time and resource constraints)
	For consistency with reform-based science teaching
	Other
When teachers analyze curriculum materials	Before instruction
	During instruction
	After instruction
How teachers analyze curriculum materials	Large-scale changes (omitting, supplementing, adding lessons)
	Small-scale changes (more subtle changes within lessons)
Factors impacting preservice teachers' knowledge and beliefs	Science methods course
	Mentor teacher's planning practices
	Other

ity of mentor teachers, curriculum developers, and future colleagues. We developed these codes from the questions in the interview protocol. We then identified patterns among the interviewees' responses and examined changes in these patterns across time. This analysis shed light on the preservice teachers' confidence level with analyzing science lesson plans, their perceptions of the factors impacting their confidence level, and any changes in their perceptions over time.

Other analysis. A second independent rater coded a subset of the data (10%). Relative observed percent agreement was 88%, and Cohen's kappa coefficient was 0.76, indicating substantial agreement.

RESULTS

The first section describes the preservice teachers' analysis ideas and changes in these ideas as they learned about reform-based criteria. The second section examines the preservice teachers' knowledge and beliefs about curriculum design and confidence level with engaging in this teaching task as well as changes in their knowledge, beliefs, and perceptions during the course and student teaching.

TABLE 3
Examples of Analysis Ideas Related to Reform-Based Criteria

Analysis Idea	Examples From Pretest
Learning goals	The goals are stated clearly and connections to the NSES Standards stated as well. (Ashley)
Lesson purpose	I would bring in examples from home of insulation (oven mitts, coffee thermos, etc.) so that the kids can have something to look at and relate "insulation" to. (Mia)
Students' ideas	Teacher asks students to think about the word *insulation* and if they have ever heard it before. This gets their minds going and allows them to have some ideas without the teacher telling them the answer. (Teresa)
Phenomena	I would also have my students write down their observations each time they look at the ice cube in its container. They could create a chart of these observations in order to share them with their classmates during the following session. (Morgan)
Sense making	Vague directions for leading the discussion in section two. Perhaps some questions could be included to help guide student discussion and help them come to correct findings. (Karen)
Assessment	I feel the science notebooks are a way for the teacher to assess if the students understood the lesson and what insulation does. (Debbie)
Accessible science	Students could research other cultures in hot climates or in cold climates. The class could compare the similarities/differences between the ways the cultures deal with temperature extremes. (Leah)

Analysis Ideas

When completing the pretest, the preservice teachers mentioned a range of analysis ideas. Some of these ideas connected to the reform-based criteria that they would later learn about in the course (see Table 3 for examples). Half or more of the preservice teachers also used or mentioned the following analysis ideas: making science fun and engaging; providing students with hands-on activities; making the lesson procedure clear and feasible; managing the class; providing students with clear definitions and explanations; enabling students to develop their own investigations; and promoting cooperative learning (see Table 4 for examples). Unlike the reform-based criteria, these ideas mainly emphasized the affective and practical aspects of instruction.

In the pretests, there was no significant difference in the frequency of analysis ideas that the preservice teachers mentioned related to the reform-based criteria versus other types of criteria (see Table 5). However, in the posttests, over half of the class (14/24) described more ideas related to

TABLE 4
Examples of Analysis Ideas Related to the Practical and Affective Aspects of Instruction

Analysis Idea	Examples From Pretest
Fun and engagement	The task given to students appears to be very engaging: "Can our group keep our ice cube the longest??" (Lisa)
Clarity and feasibility	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)
Hands-on activities	Actual experiment: investigative, hands-on, and involved. (Maria)
Classroom management	Experiments should be placed somewhere out of view while ice cubes are melting so that students aren't distracted by them. (Jackie)
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)
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)
Student directedness	[Lesson] allows the students to investigate and build their own containers based on their thinking. (Debbie)

reform-based science teaching than ideas related to the practical and affective aspects of instruction. Specifically, each preservice teacher, on average, attended to roughly two-thirds of the reform-based criteria (4.29/7, 62%) but far fewer of the other analysis ideas (2.71/7, 39%; see Table 5). These results show that the preservice teachers attended to more complex ideas about teaching after learning about the reform-based criteria in the course.

Additionally, roughly two-thirds of the class (17/24) attended to more aspects of reform-based science teaching by the end of the course. Specifically, each preservice teacher, on average, applied significantly more reform-based criteria in the posttests (4.29/7, 62%) than in the pretests (2.50/7, 36%). However, there was no statistically significant difference from pre (3.33/7, 48%) to post (2.71/7, 39%) in the frequency of ideas related to the practical and affective aspects of instruction (see Table 5). See Figures 1 and 2 for examples of these trends.

Four of the seven interviewees (Karen, Leah, Ashley, and Teresa) were among the people in the class who demonstrated a shift in analysis ideas from pre to post. In the interviews they noted a shift toward more central issues of teaching, as illustrated in Ashley's response:

TABLE 5
Mean Number of Analysis Ideas Related to Reform-Based Criteria Versus Other Aspects of Instruction Within Pre-/Posttests

Analysis Ideas Related To . . .	Pretest		Posttest		*t*-Value[b]	Effect Size[c]
	Mean[a]	SD	Mean	SD		
Reform-based science teaching	2.50	1.29	4.29	1.90	4.343***	1.12
Other aspects of instruction	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 analysis ideas that each preservice teacher applied in their analysis; maximum number of analysis ideas related to reform-based criteria = 7; maximum number of analysis ideas related to other aspects of instruction = 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. $*p < .05$, $**p < 0.01$, $***p < 0.001$.

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? . . . I just really focused on the actual lesson and not just the technicalities of the lesson, the second time around. (Interview 2)

However, the analyses of the other three interviewees (Lisa, Chelsea, and Shelley) did not differ in focus from pre to post. Lisa recognized this lack of change in her posttest, saying:

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]. (Interview 2)

During student teaching, only five of the seven interviewees had the opportunity to teach science. Of these individuals, all five of them described making adaptations to their science lesson plans before teaching them. In their adaptations, the interviewees focused on only one of the seven reform-based criteria in their science planning—attending to learning goals (3/5). Instead, the interviewees tended to focus on the practical and affective aspects of instruction, such as managing the class (2/5), making science fun and engaging (2/5), and providing clear explanations and definitions for students (2/5). They also added a focus on adapting for the needs of specific students (3/5) (see Table 6 for examples). These

Summary: Kylie focuses largely on ideas related to the practical and affective aspects of instruction, including science as fun and engaging, cooperative learning, and clarity of procedures. She mentions only one idea related to the reform-based criteria: assessing student learning.

Excerpt from Kylie's pretest:

"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?"

FIGURE 1. Example of analysis ideas from Kylie's pretest.

results show that the preservice teachers continued to focus on the practical and affective aspects of instruction during student teaching (with an added focus on students) but placed less emphasis on the reform-based criteria, in comparison to their analysis ideas at the end of the methods course.

Knowledge and Beliefs About Curriculum Materials Analysis

At the beginning of the methods course, all of the interviewees viewed curriculum design as an authentic teaching practice. Karen shared this perspective in the following excerpt: "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" (Interview 1).

Even though the preservice teachers viewed curriculum design as important, they initially held several undeveloped ideas about when, how, and

Summary: Kylie focuses her analysis on several reform-based criteria, including eliciting students' prior knowledge and predictions, providing experiences with phenomena, and assessing student learning, and she attends to multiple aspects within each criterion.

Excerpt from Kylie's posttest:

"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…[T]hey 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,…I think that having 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."

FIGURE 2. Example of analysis ideas from Kylie's posttest.

TABLE 6
Examples of Main Analysis Ideas Applied During Student Teaching

Criteria	Example
Learning goals	To prepare for my unit I had looked up the [state standards] for science. . . . Even though this is the curriculum we are using, are these things that they even really need to know right now? I was just looking for the key concepts, big ideas, the things I knew that they would be able to take away with them. (Leah)
Classroom management	I also thought about . . . classroom management because it was like, okay, how are 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 and engagement	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. (Chelsea)
Explanations and definitions	Even though I do see the value in trying to get [my students] 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)
Specific students	I modified almost every lesson for my kids because they need more time, and they need it to be as explicit as possible. . . . We have six kids who are certified as special needs: two kids were just decertified, one kid who is diagnosed ADHD, two kids who should be diagnosed, and one 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)

why teachers modify lesson plans. First, the majority of the interviewees expressed a narrow view of *when* teachers engage in design work. All seven interviewees recognized that teachers modify curriculum materials during and after instruction, but five of them did not discuss the design work that occurs during planning. Second, in describing *how* teachers adapt lesson plans, six of the seven interviewees focused on the changes that teachers make to the structure of lessons and units, which include omitting, supplementing, or substituting lessons or portions of lessons (Drake & Sherin, 2006). Leah illustrated this point: "I don't think that you necessarily have to follow [curriculum materials] by the book. Bring in other things, maybe find things online, or find other activities for them to do just to change things up" (Interview 1). Even though the interviewees were able to con-

ceptualize curriculum design in terms of large-scale changes, they rarely mentioned the more subtle changes that teachers make within lessons.

Third, at the start of the course, the interviewees identified two reasons *why* teachers engage in curricular analysis. All of them recognized that teachers take into account specific student needs. Chelsea explained, "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 interviewees also stated that teachers consider their own teaching style, as illustrated in Teresa's response, "The teacher has to personalize [curriculum materials] to what they are comfortable with and how they want to teach it. Like a lesson that my teacher does, I would have to adapt it just because my personality is different" (Interview 1). The preservice teachers' initial ideas about why teachers engage in curriculum design were limited to these two reasons.

After experiencing the methods course, the preservice teachers refined their ideas about curriculum design. First, all of the interviewees recognized that teachers engage in curricular decision making not only during and after instruction but also before they teach their lessons. For example, Teresa highlighted the analysis work that teachers do in preparing to teach, saying, "Teachers are always changing lessons when they plan for instruction. I think people are even doing it without realizing it. They use the curriculum but then add something they noticed from their class or something they want to emphasize" (Interview 2). During student teaching, the interviewees continued to recognize that teachers modify lessons during all phases of instruction.

Second, in considering *how* teachers modify curriculum materials, all of the interviewees recognized that teachers make small-scale changes within lesson plans, not just adaptations to the structure of lessons or units. For example, in describing her use of curriculum materials, Teresa noted several subtle changes she would make: "[T]here 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 . . . or I'll change the lesson around a little bit to address the learning goal" (Interview 2). The interviewees continued to see the importance of both small- and large-scale changes during student teaching.

Third, in discussing *why* teachers engage in design work, three of the seven interviewees (Karen, Leah, and Ashley) expanded their ideas. (These interviewees were the same ones who demonstrated a greater focus on analysis ideas related to reform-based science teaching in the posttests.) Along with recognizing that teachers modify for specific students and teaching styles, these preservice teachers added the idea that teachers also adapt curriculum materials to improve the quality of instructional support provided for all students and maintained this belief during their student teaching semester. Leah shared this new idea in the following response:

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. (Interview 2)

These interviewees also recognized that they could use the reform-based criteria to help them improve the quality of the instructional support provided within lessons. Karen explained, "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" (Interview 2).

Despite these changes in ideas about *why* teachers analyze curricular resources, the ideas of the other four interviewees (Lisa, Chelsea, Shelley, and Teresa) remained unchanged by the end of the course and student teaching. These individuals also viewed the reform-based criteria as beneficial only if teachers adapted them for their students and teaching styles. For example, Lisa responded:

These [criteria] are general enough where you could adapt to fit your style, to fit your students. So like, how I might promote student sense making and how another teacher promotes sense making might come about in different ways. So I just think that there are different ways. (Interview 2)

Lisa failed to see that the reform-based criteria were a means to improve the quality of instructional support within lessons, regardless of specific students and teaching styles, and that some pedagogical methods might be more effective than others. Similarly, Chelsea and Teresa stated that there is not one criterion that is important for all teachers to consider in planning, even when asked about specific criteria, such as aligning learning goals with activities and helping students see the lesson purpose as meaningful. Teresa explained, "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" (Interview 2). Chelsea shared similar thoughts: "The criteria 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" (Interview 3).

Three of these four interviewees (Lisa, Chelsea, and Shelley) did not use the reform-based criteria in the posttests. Lisa shed some light on why this was the case, saying:

If I was doing [the analysis] for a class, I'm just gonna read [the lesson plan] through, see what pops out at me. If I'm in an actual classroom and have worked with the kids for a while, I'd have some ideas of what I want to get out of [the lesson] before even looking at it . . . 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. (Interview 2)

Taken together, these findings show that by the end of the course and student teaching, some preservice teachers continued to focus exclusively on adapting lessons for students and teaching styles and did not view the reform-based criteria as relevant in and of themselves but only as relevant if teachers think they are useful for their particular context and preferences.

Factors Impacting Preservice Teachers' Knowledge and Beliefs About Curriculum Materials Analysis. Two main factors mediated the changes or lack of changes in the interviewees' knowledge and beliefs about curricular analysis. All seven interviewees pointed to the science methods course as a contributing factor in shaping their ideas about curriculum design—in particular, learning about the reform-based criteria and applying those criteria in the analysis of lesson plans. Shelley replied, "The [analysis assignments] have really helped to show me that, yeah, there are some great lessons out there but there are things that maybe need to be tweaked in them" (Interview 2).

Six of the seven interviewees mentioned that their mentor teacher also shaped their ideas about curriculum design. They observed their mentor teacher modify materials in preparing to teach, not just during and after instruction. Shelley commented, "When I asked my [mentor 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" (Curriculum materials use assignment). The preservice teachers also observed their mentor teacher make small-scale modifications, not just large-scale adaptations. Ashley commented, "The lesson started to have the students work on their journal pages by themselves, but [my mentor teacher] decided to go through the first two questions as a whole class and the third one . . . by themselves" (Curriculum materials use assignment). These findings show that the interviewees' interactions with their mentor teacher supported the ideas emphasized in the methods course about *when* and *how* teachers analyze materials.

However, the preservice teachers did not experience the same continuity in learning *why* teachers analyze curriculum materials. For example, in the curriculum materials use assignment, the interviewees observed their mentor teachers plan lessons based on resource and time availability (3/7), teaching style (4/7), fun and engagement (4/7), students (5/7), and local standards (2/7). With the exception of the last one, the mentor teachers did not discuss adaptations related to reform-based science teaching. (In fact, the ways that the classroom teachers adapted lessons overlapped significantly with the kinds of adaptations the preservice teachers made during their student teaching, as described above.) Because the interviewees did not perceive that their mentor teachers modified materials to align them with reform-based standards and practices—an important reason emphasized in the course—the field experience failed to reinforce the same ideas about *why* teachers engage in design work.

Confidence Level With Analyzing Curriculum Materials

At the start of the course, four interviewees said they felt uncomfortable analyzing science lesson plans due to insufficient science subject matter knowledge and limited knowledge about how to teach science. The other interviewees reported feeling comfortable with design work. Some felt that they had sufficient science subject matter knowledge for teaching elementary school students, developed from their experiences as science learners, while others did not recognize that they needed pedagogical knowledge for teaching *science*, specifically, to engage in curricular decision making. Additionally, all seven interviewees planned on following their science curriculum materials closely during their first year of teaching, due to their limited teaching experience. Chelsea explained, "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).

At the end of the course and student teaching, all but one interviewee said they felt comfortable analyzing science lesson plans. Also, those who said they felt comfortable engaging in curricular design at the beginning of the course realized that this perspective was naive. Additionally, all seven interviewees said they would feel comfortable analyzing their science curriculum materials from the very beginning of their teaching career. Chelsea shared:

> I see myself using [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. (Interview 2)

Chelsea, like her peers, began to view herself in a new light—as a confident curriculum designer ready to adapt lesson plans during her first year of teaching.

Several factors mediated changes in preservice teachers' confidence level. Learning about specific reform-based criteria expanded the preservice teachers' analysis ideas and thus increased their confidence level with curricular analysis. Chelsea explained, "At the beginning of the semester I could analyze [science lessons], but it was more narrow. . . . But now I feel more comfortable and confident 'cause I have more ideas to consider when I'm analyzing lessons" (Interview 2). Participating in repeated practice with analyzing lessons also increased the preservice teachers' confidence level with this teaching task. Shelley commented, "The practice we had with critiquing lessons . . . helped a lot . . . just going through and actually looking for some of these [criteria] really helped me feel more comfortable looking at a lesson plan" (Interview 2). Having a supportive mentor teacher also positively impacted the preservice teachers' confidence level. The interviewees explained that their mentor teachers

welcomed their suggestions and ideas. They also observed their mentor teachers adapt curriculum materials, leading the preservice teachers to conclude that it would be permissible, if not expected, for them to do the same.

DISCUSSION

Strengths in Developing Pedagogical Design Capacity

By the end of the methods course, the majority of preservice teachers considered a wider range of analysis ideas related to reform-based science teaching and applied them more often than ideas related to the practical and affective aspects of instruction. These findings are noteworthy in light of a similar study, which found that preservice teachers made little spontaneous use of reform-based criteria, viewing the criteria as "disconnected from the reality of the classroom" (Schwarz et al., 2008, p. 368). Several reasons may account for this difference in findings. The preservice teachers in this study applied the criteria as a set of questions to consider, rather than as structured analysis forms. Unlike the Schwarz and colleagues study—but because we had the benefit of building upon their findings—the preservice teachers also had several opportunities to make connections between their own analysis ideas and the reform-based criteria as well as analyze their own lesson plans, enabling them to engage in authentic analysis experiences with the criteria. These experiences may have led the preservice teachers to view the criteria as relevant, motivating their use of the criteria.

Most of the preservice teachers also experienced increased confidence in designing lessons by the end of the course and saw themselves as curriculum designers during their first year of teaching. This finding is encouraging in light of reports that novice teachers tend to stick closely to their curriculum materials, even when they are aware of the materials' weaknesses (Bullough, 1992; Grossman & Thompson, 2008; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Valencia et al., 2006). These teachers tend to have limited capacities for analyzing curriculum materials, constraining their ability to decide what and how to teach. This study, in contrast, found that the preservice teachers critiqued and adapted lessons during their student teaching and planned to do so during their first year of teaching.

The interviewed preservice teachers also expanded their knowledge and beliefs about curriculum materials analysis. Initially, some of the preservice teachers did not recognize that teachers participate in design work before instruction. However, at the end of the course, they added the idea that curriculum design takes place during planning, not just during and after instruction. The preservice teachers also recognized that teachers make small-scale changes within lessons (e.g., changing the materials used,

increasing student control over an activity), in addition to large-scale changes (e.g., adding, supplementing, and omitting lessons). Some (not all) of the preservice teachers also expanded their knowledge and beliefs about why teachers engage in design work. They recognized that curriculum materials are not always consistent with reform-based standards and practices (Kesidou & Roseman, 2002; Stern & Roseman, 2004) and thus need to be adapted to improve the quality of instructional support for all students, in addition to contextual and personal reasons.

These findings extend what we know about preservice and new teachers' knowledge and beliefs about curricular analysis (e.g., Bullough, 1992; Forbes & Davis, 2008; Nicol & Crespo, 2006; Schwarz et al., 2008; Valencia et al., 2006) by highlighting unexplored dimensions of their knowledge and beliefs. Specifically, this study sheds light on novice teachers' ideas about when, how, and why teachers engage in curriculum design work. Also, Nicol and Crespo (2006) found that preservice teachers who do not observe their mentor teacher modify lessons may develop the belief that critiquing and adapting are inauthentic teaching practices. This study provides explicit evidence for this idea, showing that preservice teachers may develop more complete knowledge and beliefs about design work if they have opportunities to learn about classroom teachers' planning practices, in addition to engaging in analysis experiences themselves.

Limitations in Developing Pedagogical Design Capacity

Even though the course promoted a principled stance toward curriculum materials, some preservice teachers, including three of the seven interviewees, attended to few reform-based criteria in their posttest analyses. Thus, their analysis ideas remained largely unchanged from pre to post. By the end of student teaching, all interviewees appropriated the considerations their mentor teachers used when planning science lessons (i.e., adapting for specific students, fun and engagement, local standards), decreasing their focus on reform-based science teaching.

One explanation for these findings is that the methods course did not adequately prepare the preservice teachers for designing lessons on their own or adapting curriculum materials from their field placements, which tended to be poorly aligned with the goals of reform-based science teaching (Forbes & Davis, 2010). (See Beyer and Davis [2012] for an in-depth description of the preservice teachers' successes and struggles in analyzing lessons.) Thus, the preservice teachers may have needed additional support in developing their capacity for engaging in less structured, and thus more challenging, analysis tasks during their student teaching.

Another explanation is that some of the preservice teachers believed that the reform-based criteria were only relevant if teachers thought they were useful for their particular contexts and teaching styles. They did not see the criteria as relevant, in and of themselves, for improving the quality

of instruction for all students. These preservice teachers may have developed this belief due to conflicting ideas between the methods course and field placements about the reasons why teachers modify curriculum materials. The methods course emphasized the importance of modifying materials to make them more consistent with reform-based goals and practices, but the preservice teachers observed their mentor teachers modify lessons for other reasons—for specific students, teaching styles, and learning goals. Previous research has shown that preservice teachers may experience differing perspectives between methods courses and field experiences on curriculum materials use (Nicol & Crespo, 2004; Schwarz et al., 2008). For example, Schwarz and colleagues (2008) found that none of their preservice teachers viewed curricular analysis as authentic or relevant, in part, because they did not observe their mentor teachers engage in this practice. This study extends these findings by showing that preservice teachers may experience a disconnect between their methods course and field placements with regard to the reasons *why* teachers engage in this design work, impacting preservice teachers' capacity for planning lessons.

IMPLICATIONS

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). This study, given its focus on preservice teachers and science curriculum materials, helps inform the field's theoretical understanding of this participatory relationship. First, preservice teachers' knowledge and beliefs about the authenticity of curriculum design (including when, how, and why teachers analyze curriculum materials) and their vision for how they see themselves using materials in future practice may shape their ideas about the role of curriculum materials in teaching science. Preservice teachers' confidence level with curricular decision making may also mediate their use of curriculum materials, shaping whether they see design work as a stabilizing experience or not. Finally, their pedagogical design capacity may influence the degree to which they engage in a principled, reform-oriented analysis when creating learning opportunities for students.

In addition to these personal resources, this study also suggests other factors to consider in this participatory relationship. First, the quality of the curriculum materials themselves may influence novice teachers' curricular planning practices (Beyer & Davis, 2012; Forbes & Davis, 2010). Novices may be more likely to engage in productive analyses if they are provided with lesson plans that are consistent with reform-based goals and practices. Second, the use of tools plays an important role in scaffolding teachers' interactions with curriculum materials (Davis, 2006; Schwarz et al., 2008). This study examined the use of reform-based criteria as a tool and found

that criteria may help preservice teachers begin to develop analytical, reform-based stances toward science curriculum materials. Third, the multiple settings that preservice teachers navigate (i.e., methods courses, field placements) also shape how preservice teachers use curriculum materials (Schwarz et al., 2008). This study found that different contexts may promote conflicting knowledge and beliefs on curriculum materials use, constraining preservice teachers' actions as they engage in curriculum design.

Design Implications for Science Teacher Education

This study provides insight into instructional strategies that teacher educators may use to foster effective participation with curriculum materials. These strategies may extend to both teacher preparation and induction programs. To help develop their pedagogical design capacity for reform-based curriculum design, preservice teachers may benefit from learning about the goals and practices of reform-based science teaching and applying these as criteria in the analysis of lessons. Many existing science curriculum materials do not represent ideas about effective science teaching and thus need to be adapted to make them more consistent with reform-based standards and practices (Beyer et al., 2009; Forbes & Davis, 2010; Kesidou & Roseman, 2002; Stern & Roseman, 2004). This study also found that some preservice teachers may fail to modify lesson plans in reform-oriented ways if they did not see their mentor teachers make adaptations for this reason. Therefore, novice teachers may benefit from opportunities to work with mentor teachers who uphold a principled, reform-based stance toward curriculum materials. This mentorship may help promote consistent ideas about the use of curriculum materials between their methods course and field experiences, and in turn, help novices develop their pedagogical design capacity during and following the course.

Preservice teachers also need opportunities to refine their knowledge and beliefs about *when* and *how* teachers analyze curriculum materials. Teacher educators may engage preservice teachers in modifying existing lessons as they plan for instruction, like in this study. In doing so, this experience may help them see that teachers make adaptations during the planning phase of instruction and make both small- and large-scale modifications. This study also found that having preservice teachers observe their mentor teachers' planning practices may help them expand their ideas about when and how teachers engage in curriculum design.

Finally, teacher educators need to help preservice teachers develop their ideas about the reasons *why* teachers analyze curriculum materials. Specifically, this study found that preservice teachers recognized that curriculum materials need to be modified for specific students and teaching styles but had difficulty understanding that curriculum materials also need to be made more consistent with reform-based standards and practices—changes

that are independent of specific preferences and contexts. This study identifies this as an important area in which preservice teachers need support. However, additional research is needed to discern what instructional strategies might be useful in supporting preservice teachers in expanding their knowledge and beliefs about the reasons why teachers engage in curricular decision making.

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