Helping Elementary Preservice Teachers Learn to Use Curriculum Materials for Effective Science Teaching

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Received 7 March 2007; revised 20 August 2007, 4 September 2007; accepted 10 September 2007

DOI 10.1002/sce.20243
Published online 8 February 2008 in Wiley InterScience (www.interscience.wiley.com).

ABSTRACT: Curriculum analysis, modification, and enactment are core components of teacher practice. Beginning teachers rely heavily on curriculum materials that are often of poor quality to guide their practice. As a result, we argue that preservice teachers need to learn how to use curriculum materials for effective teaching. To address this concern, the authors conducted a study in which three teacher educators taught elementary science methods courses incorporating a major focus on curriculum analysis and modification based on Project 2061 Instructional Analysis Criteria. Analysis of pre–post assessments, classroom

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artifacts, classroom dialogue, and postcourse interviews indicated that preservice teachers accurately applied and appropriated a modest set of criteria whose intended meanings most closely matched their own understandings, were most closely aligned with their own goals and criteria, or were made accessible through systematic use and attention within the methods sections. However, many did not find the materials analysis criteria useful or comprehensible and based their curricular decisions on their own criteria. Furthermore, some preservice teachers resisted engaging in these practices that may have seemed too analytical, inauthentic, and destabilizing. These findings pointed us toward a revised theoretical framework and new approaches to better support preservice teachers’ effective participation with curriculum materials. © 2008 Wiley Periodicals, Inc. Sci Ed 92:345–377, 2008

INTRODUCTION

Using curriculum materials is a core component of teacher practice. Teachers need to analyze, modify, and enact curriculum materials in a principled, reform-based manner for effective science teaching. Elementary preservice teachers are particularly dependent on curriculum materials to guide their teaching (Grossman & Thompson, 2004; Kauffman, Johnson, Kardos, Lui, & Peske, 2002; Mulholland & Wallace, 2005) and to support their often-weak science knowledge as they begin their careers (Abell, Bryan, & Anderson, 1998; Chochran & Jones, 1998; Davis, Petish, & Smithey, 2006). The situation is especially problematic when the materials are of poor quality (Kesidou & Roseman, 2002; Stern & Roseman, 2004), inconsistent with reform-based standards and practices, or poorly matched with learners and their communities. This work reports on our efforts to help preservice elementary and middle school teachers develop professional knowledge and beginning skills in curriculum analysis and modification in order to develop productive practices for using science curriculum materials.

We define curriculum as the learning goals that underlie instruction and curriculum materials as the materials that help the teacher address the learning goals. Curriculum materials include all of the books, guides, and kits that influence the planned and enacted curriculum (Ball & Cohen, 1996; Brown & Edelson, 2003; Grossman & Thompson, 2004; Kesidou & Roseman, 2002; Remillard, 2005). The planned curriculum refers to the teacher’s lesson plans, whereas the enacted curriculum refers to the events that are enacted within the classroom (Remillard, 2005). We adopt the term “using curriculum materials” to describe practices including materials analysis, modification, and enactment.

WHY PREPARING TEACHERS TO USE CURRICULUM MATERIALS IS IMPORTANT

In agreement with others (e.g., Davis, 2006), we argue that teacher educators must help new teachers learn to use curriculum materials effectively in their planning and teaching for several reasons. In the classroom, teachers and students are co-constructors of the enacted curriculum (Ball & Cohen, 1996; Brown & Edelson, 2003; Grossman & Thompson, 2004). Curriculum materials influence teachers’ pedagogical decisions, shape teachers’ design of their planned curriculum, and serve as a source of teachers’ learning (Ball & Cohen, 1996; Ball & Feiman-Nemser, 1988; Brown & Edelson, 2003; Collopy, 2003; Davis & Krajcik, 2004; Grossman & Thompson, 2004; Remillard, 2005; Wang & Paine, 2003). Thus, through their influence on teachers’ knowledge and plans, curriculum materials play an important role in determining the enacted curriculum.

Furthermore, most current science curriculum materials are not of high quality and fail to support students in achieving specified learning goals (Kesidou & Roseman, 2002; Stern &
Roseman, 2004). This situation is highly problematic because new teachers, in particular, tend to rely heavily and uncritically on curriculum materials to determine what and how to teach (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Kauffman et al., 2002; Mulholland & Wallace, 2005). As a result, when they encounter weak materials, they may not recognize the weaknesses and thus fail to make appropriate modifications. Similarly, when they encounter stronger materials, they may not recognize the affordances the materials offer and may unintentionally leave out or modify parts of lessons that are essential to helping students achieve the learning goals (Ball & Feiman-Nemser, 1988; Brown & Campione, 1996; Grossman & Thompson, 2004).

The varied and often poor quality of curriculum materials for teachers’ use in addressing grade-level standards makes teacher analysis and modification of curriculum materials a prominent issue. Historically, however, learning to use curriculum materials has not been a key feature of science methods courses. New teachers sometimes leave their methods courses believing that good teachers should not use curriculum materials (Ball & Cohen, 1996; Ball & Feiman-Nemser, 1988). At other times, they believe they should follow the curriculum materials exactly as scripted. Limited research about supporting new teachers’ use of curriculum materials in science education is available to guide science teacher educators (Davis, 2006; Davis et al., 2006).

Curriculum materials can also serve as a source for teacher learning. Some materials include supports for teacher learning (Davis & Krajcik, 2004). Yet, new teachers often do not have the resources and skills necessary to know how to take advantage of these special features. Helping new teachers learn to use curriculum materials may help them plan and teach lessons that support students in achieving specified learning goals and at the same time help them increase their own professional knowledge (Ball & Feiman-Nemser, 1988; Ben-Peretz, 1990; Collopy, 2003; Grossman & Thompson, 2004; Smith, 2001).

OVERVIEW

We aimed to help new teachers learn to effectively use curriculum materials as part of their teaching practice. Within three sections of an elementary science methods course, we engaged preservice teachers in analyzing and modifying curriculum materials in a principled manner based on American Association for the Advancement of Science (AAAS) Project 2061 Instructional Analysis Criteria (DeBoer et al., 2004; Kesidou & Roseman, 2002; Stern & Roseman, 2004). We hypothesized that introducing these criteria as a tool would support preservice teachers in learning to make effective use of curriculum materials. In particular, we hypothesized that introducing preservice teachers to well-specified, standards-based criteria and modeling and scaffolding their use would support their learning how to evaluate whether or not materials address a specified learning goal, recognize strengths and weaknesses of the materials, and make appropriate modifications to the materials. We further hypothesized that this approach would explicitly communicate components of reform-based teaching, and help preservice teachers refine their views of the role of science curriculum materials. A more elaborated model of this process will be described in the theoretical framework section. Our instruction using the criteria was aimed at developing preservice teachers’ professional knowledge and scaffolding preservice teachers’ practices using curriculum materials over the course of the semester.

This effort builds on and adds to prior work (Davis, 2006) in several ways. While our work also engaged preservice teachers in the authentic practices of analyzing curriculum materials and using those analyses to plan and teach science lessons, our approach introduced preservice teachers to reform-based criteria (Project 2061 Criteria) used at the national level to critique curriculum materials. Rather than developing and refining preservice teachers’
own criteria (Davis, 2006), we primarily used the categories and language of the Project 2061 Criteria to scaffold preservice teacher’s reform-based interactions with curriculum materials. As such, the nature of the criteria (e.g., level of specificity, the language used to elaborate the criteria) as well as their substance differed from Davis (2006). It was our goal to determine whether these criteria could serve as effective scaffolding for preservice teachers using curriculum materials with respect to multiple challenging dimensions of reform-based teaching.

Second, while our work examined the type and application of analysis criteria within preservice teacher’s use of curriculum materials (as did Davis, 2006), we also analyzed patterns of curriculum use from class transcripts, preservice teacher interviews, and essays across multiple methods course sections. Our analysis of these additional data sources led to determining likely causes for our outcomes and important factors to consider in revising theoretical frameworks (e.g., Remillard, 2005) for understanding how preservice teachers use curriculum materials.

**RESEARCH QUESTIONS**

Our research goal was to determine what preservice teachers learned about using curriculum materials from our instructional approaches that emphasized use of Project 2061 Instructional Analysis Criteria for analyzing, modifying, and enacting science instruction. In addition, we examined how preservice teachers engaged in curriculum analysis and modification and what attitudes preservice teachers expressed toward curriculum materials analysis and modification.

To determine the effect of our instructional approach using Project 2061 Criteria to scaffold the development of preservice teachers’ productive practices using curriculum materials, we asked the following research questions:

1. How did preservice teachers apply the analysis criteria within well-structured tasks of analyzing materials with respect to the criteria? Did they apply the criteria in ways that were consistent with Project 2061’s reform-based intentions?
2. How did preservice teachers use the Project 2061 Criteria when analyzing or planning and modifying curriculum materials in open-ended tasks?

Aside from the use of the Project 2061 Criteria, we also examined how preservice teachers were using curriculum materials more generally. We asked,

3. What other criteria did preservice teachers use in analyzing lessons in curriculum materials?

Finally, we explored how preservice teachers reacted toward curriculum materials analysis and modification using the criteria. We asked,

4. What attitudes did preservice teachers express toward analyzing, planning, or modifying materials with the criteria? What reasons did preservice teachers express for those attitudes?

The paper describes our theoretical framework, methods, findings, and interpretations of the outcomes. In particular, we discuss implications for teacher learning and some opportunities and challenges of helping preservice teachers develop productive practices for using curriculum materials. Finally, we suggest important factors to consider in revising a theoretical framework, and elements of a promising new approach for addressing the challenges we identified in helping preservice teachers use curriculum materials for effective science teaching.

*Science Education*
FRAMEWORKS

This section explains the theoretical frameworks guiding our work and the conceptual frameworks used in the science methods course.

Theoretical Framework

This paper takes the theoretical perspective that teachers participate with curriculum materials in the design of the planned curriculum (Remillard, 2005). In other words, teachers interact with curriculum materials when constructing the planned curriculum. This planned curriculum guides the teacher in co-constructing the enacted curriculum with the students. The nature of teachers’ participation with curriculum materials depends on what both the teacher and the curriculum materials bring to the interaction.

Teachers bring a range of knowledge, skills, beliefs, goals, and identities to participating with curriculum materials (Remillard, 2005). They use subject matter knowledge, pedagogical content knowledge, and knowledge of the curriculum to match curricular goals, pedagogy, and student-learning needs (Ben-Peretz, 1990; Carlsen, 1991; Shulman, 1987). Furthermore, teachers’ beliefs about the subject area, teaching, their students, and curriculum materials influence their interactions with curriculum materials. It is for this reason that two teachers may plan and enact different curricula from the same materials.

Curriculum materials are tools that are the product of social activity (i.e., they are constructed within cultural, historical, and institutional settings) (Brown & Edelson, 2003; Wertsch, 1991). They provide representations of knowledge, tasks, and instructional approaches that can inform and influence teachers’ practice. Curriculum materials reflect multiple ideas, values, and meanings about content and teaching. How teachers read, interpret, and use curriculum materials depends on the meanings they themselves construct and infer. Through conveying ideas, meanings, and values through, curriculum materials can greatly influence teachers’ actions, their planned curriculum, and the resulting enacted curriculum (Brown & Edelson, 2003; Enfield, Smith, & Grueber, 2006; Remillard, 2005). However, these meanings and values may or may not be explicit or accessible to teachers.

Remillard’s participatory model is useful for describing how teachers and curriculum materials interact in the design of the planned curriculum. For example, teachers may follow materials closely, adapt materials to meet their needs, or use materials as a seed for innovation (Brown & Edelson, 2003). We argue that teachers should analyze strengths and weaknesses of curriculum materials, make modifications to compensate for deficiencies, and take advantage of affordances that curriculum materials offer. By participating with curriculum materials in this manner, teachers can develop a planned curriculum that supports students in achieving specified learning goals.

However, given that preservice teachers do not often bring the necessary resources to participate with curriculum materials in an analytical manner, and given that meanings and values that curriculum materials bring are often hidden or implicit, we recognized the need for developing tools for mediating or scaffolding teachers’ participation with materials. Tools, such as reform-based criteria and instructional models, can serve to mediate or support the teacher-curriculum interactions (e.g., in curriculum analysis, planning, and modification) by providing well-specified language for mediation, lenses with which to interact with materials, and qualities to which materials can be held accountable. Furthermore, these tools and their use in curriculum materials practices can be modeled in an instructional setting, then scaffolded and faded (Brown, Collins, & Druguid, 1989) to help preservice teachers develop professional knowledge and practices.
Conceptual Framework in the Course: Project 2061 Instructional Analysis Criteria and Experiences Using Curriculum Materials

To scaffold preservice teachers’ practices for using curriculum materials as described above, we introduced the AAAS Project 2061 Instructional Analysis Criteria as a tool for analyzing curriculum materials. The Project 2061 Criteria may be used to evaluate how well materials address specified learning goals and support teachers and students in achieving those learning goals (DeBoer et al., 2004; Kesidou & Roseman, 2002; Stern & Roseman, 2004). The Project 2061 Criteria favor materials that establish a sense of purpose, engage students with scientific phenomena, elicit and address student ideas about phenomena, present students with scientific ideas, provide students with opportunities to use scientific ideas and apply them to new situations, provide teachers with effective assessments of student progress, and provide enhanced learning environments for all students.

By using these criteria, we hypothesized that preservice teachers would better understand the dimensions of reform-based teaching that are foregrounded in the criteria. Furthermore, we anticipated that the preservice teachers might use them as tools for analyzing and modifying curriculum materials to increase the effectiveness of their science teaching. For example, the Project 2061 Criterion about opportunities for application of new ideas could help a teacher analyze a set of curriculum materials and decide that the materials lack opportunities for application and practice of the learning goal. Then, the preservice teacher might add or enhance such activities suggested in the materials to provide students with more practice using new ideas, thereby enacting a more effective curriculum for her students. In this manner, the Project 2061 Criteria become tools that mediate preservice teacher interactions with curriculum materials.

Consistent with a cognitive apprenticeship perspective, we suggest that preservice teachers need many opportunities to practice analyzing curriculum materials with guidance. These opportunities include a range of experiences such as participating in science lessons that meet the criteria, looking at sample materials analyses completed by in-service teachers, analyzing how well sample materials address particular learning goals as well as other criteria, and planning lessons using those materials for teaching in the field.

We theorize that a preservice teacher in her future classroom might, as a result of engaging in the experiences described above, take an analytical approach to using curriculum materials and use the instructional criteria to determine the strengths and weaknesses of new curriculum materials for helping her students achieve various learning goals or to help with curricular adoption. An analytical stance and knowledge of the material’s strengths and weaknesses might help her make modifications to compensate for the weaknesses of those materials and take advantage of their strengths as well as make more thoughtful decisions about choosing a curriculum.

SCIENCE METHODS COURSE DESCRIPTIONS

This study took place in three sections of a one-semester elementary science methods course at a large midwestern university. Authors Schwarz, Gunckel, and Smith each taught one section. To protect the anonymity of the participants, we use the pseudonyms of Jacobs, Miller, and Banks to refer (though not in this particular order) to the instructors of the methods sections. Preservice teachers enrolled in this course in their fourth year of a five-year teacher education program. The course includes a field observation and teaching component. The methods course is designed to develop basic knowledge and practices of science teaching and is built around the planning and teaching of activity sequences (mini units). The preservice teachers planned and taught a mini unit in their field placement.
classrooms. The course emphasized curriculum materials analysis and modification as an essential feature of planning and teaching science.

Aside from introducing preservice teachers to the Project 2061 Criteria and using curriculum materials, each instructor for the methods sections framed their course around broad goals. Those course goals included helping preservice teachers understand and be able to engage their own students in scientific practices, bridging students’ cultural resources with those of science, or developing preservice teachers’ professional knowledge through the use a conceptual change approach in unit planning. Each instructor shaped the use of the Project 2061 Criteria to fit with these broader course goals by selecting a subset of the Project 2061 Criteria, modifying some criteria, and innovating others to introduce to preservice teachers. See Table 1 for a synthesis of course similarities and differences and criteria used as well as Appendix A for a description of the categories and criteria used in the different methods sections.

Course instructors also introduced instructional models built on a learning cycle framework (Abraham, 1998). We define an instructional model as a framework that outlines activity sequences and specifies activity functions within those sequences (Smith, 2001). While there were variations in the particular models used (Schwarz & Gwekwerere, 2007; Smith, 2001), all three sections introduced the idea of an instructional model and used the Biological Sciences Curriculum Study “Five Es” as one example (Bybee, 1997; Trowbridge, Bybee, & Powell, 2004). While the impact of introducing the instructional models is described elsewhere (Gunckel, Bae, & Smith, 2007), the use of additional frameworks in the course is relevant to the outcomes of this instructional trial as well as to future directions.

DATA SOURCES AND ANALYSES

We analyzed multiple data sources from all three methods sections to answer our research questions. Our theoretical framework pointed us toward investigating the preservice teacher and curriculum materials interaction with a specific focus on role of the criteria in scaffolding that interaction. As a result, our data collection and analysis is aimed at determining how the criteria were applied within structured and open-ended contexts (analyzing specific criteria use and lesson planning that might invoke such use), and in determining emergent factors and issues in preservice teachers’ curriculum materials use (through written pre–post curriculum analysis and interviews).

Table 2 outlines the data sources obtained from each course section and how the data were analyzed. Table 3 outlines which data were used to answer our research questions. We note that the differences in data collection and analysis between the course sections are due to normal variation in instructional approaches to meet the larger course goals and the needs of the preservice teachers in the courses. Variation in instructional approaches naturally led to slightly different forms of data collection and subsequently to data analysis that were nonetheless generally comparable. All instructor-authors shared the goal of infusing curriculum materials use into our sections, planned the undertaking of this study before the course was taught, and found similar patterns underlying the outcomes.

The following section describes our main data sources and their analyses used in the three methods section to address our research questions. In addition to Table 2, further detailed information about our data sources and analyses are available in our technical document (http://www.msu.edu/~cschwarz).

Unit Analysis Forms and Curriculum Materials Analysis Forms

We analyzed preservice teachers’ unit analysis forms and curriculum materials analysis forms to determine how preservice teachers applied the criteria. The forms for analyzing
TABLE 1
Course Similarities and Differences Across Instructors

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Banks</th>
<th>Miller</th>
<th>Jacobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course emphases</td>
<td>Developing an understanding of and skills for enacting scientific practices, particularly model-centered scientific inquiry. Using instructional models and Project 2061 Criteria as indicators of effective teaching and for evaluating lesson plans.</td>
<td>Understanding learning goals, taking account of students’ cultural backgrounds, analyzing strengths and weaknesses of curriculum materials, and making modifications while planning and enacting lessons using Project 2061 Criteria.</td>
<td>Unit planning as repeating “professional learning cycles” through which teachers’ knowledge is constructed. Using frameworks (e.g., instructional models such as conceptual change), analyzing strengths and weaknesses of curriculum materials, and making modifications while planning and enacting lessons using Project 2061 Criteria.</td>
</tr>
<tr>
<td>Project 2061 Criteria</td>
<td>0—Learning Goal IA—Sense of Purpose II—Student Ideas IVF—Providing Practice VI—Assessing VIIC—Welcoming All Students</td>
<td>0—Learning Goal IA—Sense of Purpose IC—Sequencing II—Student Ideas IVF—Providing Practice V—Promoting Student Thinking VI—Assessing VIIC—Welcoming All Students</td>
<td>0—Learning Goal IA—Sense of Purpose II—Student Ideas III—Real World IVF—Providing Practice V—Promoting Student Thinking VI—Assessing</td>
</tr>
<tr>
<td>Innovated criteria</td>
<td>Relevant phenomena with high priority to first-hand data collection Analysis of data into patterns Creating/comparing explanations and models from patterns in data to those of others and science</td>
<td>Inquiry (experiences with phenomena, patterns in data, and explanations from evidence) Nature of science Connecting to my students (integrated into all criteria)</td>
<td></td>
</tr>
<tr>
<td>How criteria were used</td>
<td>Criteria were introduced during the middle of the semester to supplement and elaborate important dimensions of effective science teaching. Preservice teachers used criteria to critique two demonstration units, a published curriculum, and their own mini-unit plan.</td>
<td>A criterion was introduced each week with supporting readings. Preservice teachers used criteria to analyze example curriculum materials and materials they used for their mini units. They used their analysis in designing mini units.</td>
<td>Similar to Miller</td>
</tr>
</tbody>
</table>

Science Education
**TABLE 2**
Summary of Data Collection and Analysis Across Instructors

<table>
<thead>
<tr>
<th></th>
<th>Banks</th>
<th>Miller</th>
<th>Jacobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit and curriculum materials analysis forms</td>
<td><em>n = 15 preservice teachers, two forms each; each form addressed all criteria</em></td>
<td><em>n = 10–12 preservice teachers depending on the form, for 10 forms; each form addressed one criterion</em></td>
<td><em>n = 12–14 preservice teachers depending on the form, for seven forms; each form addressed one criterion</em></td>
</tr>
<tr>
<td>Explanations of how units met each criterion were rated</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0 = Does not address criterion</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1 = Demonstrates weak or partial application</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 = Demonstrates adequate application</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 = Demonstrates strong application</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanations scored 3 included additional clarity or supporting examples.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Forms were analyzed to determine whether preservice teachers considered the learning goal and whether they understood the intent of criterion. To determine whether preservice teachers understood intent of criteria, each statement was coded for whether it repeated, correctly paraphrased, or incorrectly paraphrased each criterion indicator. Each statement was also analyzed for the presence of correct or incorrect examples. Scores were averaged across all preservice teacher forms. Outcomes of these scores were then grouped into four categories similar to those of Banks, including no or inaccurate application of criteria, weak, adequate, and strong application of criteria with respect to the intended meanings. Cross-coding reliability for individual criteria ranged from 85% to 100%.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light and Shadows pre-/poststrengths and weaknesses and lesson sequences</td>
<td><em>n = 10</em></td>
<td><em>n = 8</em></td>
<td><em>n = 9</em></td>
</tr>
<tr>
<td>Pre- and post-responses to strengths and weaknesses items (Question 1) were analyzed to determine the nature and frequency of preservice teachers’ criteria. Emergent codes based on responses were developed and validated through an iterative process including coding of multiple sets of tests by multiple researchers to obtain consistency. These were subsequently matched with Project 2061 Criteria.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pre- and post-lesson sequences (Question 3) were analyzed for the extent to which they met Project 2061 Criteria. Codes were based on definitions of Project 2061 Criteria and component indicators. A lesson sequence was scored between 0 and 2 for each criterion. A lesson sequence was scored 0 if it did not meet any component of the criterion. A sequence meeting one component was scored 1. A sequence meeting two or more components was scored 2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light and Shadows video/audio recordings</td>
<td><em>n = 3 post</em></td>
<td><em>n = 2 pre and 2 post</em></td>
<td>Not collected by Jacobs</td>
</tr>
<tr>
<td>Transcripts were analyzed for emergent themes—looking for evidence of how preservice teachers applied analysis criteria, how they made decisions about modifying and adapting curriculum materials, and what kinds of attitudes were evidence in classroom talk.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pre/Post Ideal Science Statements</td>
<td>Not collected by Banks and Miller</td>
<td>Statements were analyzed for use of Project 2061 Criteria. Emergent codes were also developed to</td>
<td></td>
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<td></td>
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</tbody>
</table>

*Continued*
TABLE 2
Summary of Data Collection and Analysis Across Instructors (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Banks</th>
<th>Miller</th>
<th>Jacobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postcourse interviews</td>
<td>n = 1</td>
<td>n = 2</td>
<td>n = 5</td>
</tr>
</tbody>
</table>
| Audio transcripts were reviewed to identify emergent themes such as qualities preservice teachers sought in curriculum materials that did and did not match Project 2061 Criteria. Then, transcripts were analyzed for evidence of positive/negative attitudes toward criteria and their use; preservice teachers’ perceptions of the utility, relevance, and ease of use of criteria; and reasons for their attitudes and perceptions.

TABLE 3
Data Sources Used in Addressing Research Questions

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Question 1: Understanding and Application of Criteria</th>
<th>Question 2: Spontaneous Application of Criteria</th>
<th>Question 3: Personal Criteria</th>
<th>Question 4: Attitudes Toward Criteria and Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit and curriculum materials</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>analysis forms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light and Shadows</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td></td>
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<tr>
<td>written pre/post assessment activity</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Light and Shadows</td>
<td>×</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>video/audio recordings</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pre/post Ideal Science Statements</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postinstruction interviews</td>
<td>×</td>
<td>×</td>
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</tbody>
</table>

curriculum materials with respect to the Project 2061 Criteria were analogous, but slightly different, in Banks’s compared to Miller’s and Jacobs’s course sections.

In her section, Banks used a unit analysis form that included all nine criteria used during the semester and that was designed to help preservice teachers analyze science units. (See Appendix B for a portion of that form.) Preservice teachers in her section analyzed several science units using the nine Project 2061 and modified Project 2061 Criteria. Midway through the semester, preservice teachers analyzed an electricity unit. This evaluation activity was conducted in small groups. At the end of the semester, preservice teachers designed and enacted a mini unit plan, which they individually evaluated with respect to the nine criteria. For each criterion in the form, preservice teachers were asked to indicate whether or not the unit met the criterion, and then to explain how it did or why it did not (see Science Education
All available curriculum analysis forms were analyzed, and we report results from the 15 preservice teachers who completed both electricity and mini unit analysis forms. Curriculum materials analysis forms were used in Miller’s and Jacobs’s sections. Miller and Jacobs developed a separate curriculum materials analysis form for each criterion to scaffold the preservice teacher’s interpretation of the criterion and the documentation of supporting evidence. (See Appendix C for a sample form.) Each form stated one criterion and a series of questions or indicators with spaces for ratings and supporting evidence. The preservice teachers worked in groups to analyze curriculum materials provided by their cooperating teachers for use in planning mini units. Unlike in Banks’s section, where a single form was used several times during the semester, in Miller’s and Jacobs’s sections, the separate curriculum materials analysis forms representing different criteria were provided one at a time throughout the semester as the particular topic related to a criterion was discussed. Miller’s and Jacobs’s preservice teachers’ forms were analyzed for all preservice teachers who had given informed consent.

As the forms in Miller and Jacobs’s sections were slightly different from those of Banks, they were analyzed with a different coding scheme. Those results were nonetheless comparable to those of Banks on a scale indicating the relative accuracy of criteria application. The results were synthesized through using a four-level coding scheme applied for all three sections. The coding scheme indicates whether the preservice teachers in each section, while analyzing curriculum materials, applied and interpreted the criteria with a high (strong) level of accuracy, with a moderate (adequate) level of accuracy, with a low (weak) level of accuracy, or at the lowest level, if they did not apply or inaccurately applied the criteria.

Pre–Post Light and Shadows Assessment

The Light and Shadows Assessment is a curriculum analysis, modification, and planning instrument designed to generate information about how preservice teachers applied the evaluation criteria in an authentic and open-ended task. Preservice teachers are told to imagine that they are new second-grade teachers who need to teach a unit on light and shadows. They are given two state benchmarks that align with this topic: “Explain how shadows are made,” and “Develop an awareness of the need for evidence in making decisions scientifically.” Preservice teachers are also given six activities about light and shadows—samples from curriculum materials analogous to what they might find or be given as beginning teachers. The assessment consists of three questions. First, the preservice teachers are asked to assess strengths and weaknesses of the activities (Question 1). Second, they are asked to write a brief lesson sequence listing the order of activities they would use to address the learning goals; they are told they can use, modify, or create lessons to do this (Question 2). Third, they are asked to provide a rationale for their sequence (Question 3).

All preservice teachers in the methods sections completed the written pre–post Light and Shadows Assessment. The sample of Light and Shadows Assessments we analyzed to address our research questions was chosen to triangulate with other data such as videotape of dialog and interviews as well as to have a large enough number that it could adequately sample across the course sections. For the description of how the sample is distributed across sections and the overview description of analyses, see Table 2. Our goal for analyzing pre- and posttests for Light and Shadows questions was to determine whether there was any significant change in the use of the Project 2061 Criteria by the end of the course. In particular, this task provided information about the criteria preservice teachers used in evaluating the strengths and weaknesses of the materials or in justifying their own lesson sequences, as well as how their lesson sequences met the criteria dimensions.
Video and Audio of Preservice Teacher Dialog Around the Light and Shadows Assessment

We analyzed video and audio dialog of preservice teachers working on the Light and Shadows Assessment in Miller’s and Banks’s sections. In particular, we used the dialog to address Research Questions 2 (How did preservice teachers spontaneously use the Project 2061 Criteria?) and 3 (What personally derived criteria did preservice teachers use for analyzing curriculum materials?). We obtained video and audio of two or three groups who granted us permission to do so.

Interviews

The interviews were designed to probe general views of science teaching as well as what the preservice teachers learned about analyzing, modifying, and enacting curriculum materials. Interview data were also used to examine preservice teachers’ attitudes about using the analysis criteria and completing the associated tasks. The interview protocol included questions such as

In the methods course, you were introduced to a number of criteria to evaluate and modify curriculum. Which criteria were useful? Why did you think those criteria were useful in evaluating curriculum materials, as well as planning and teaching? How would your future use of curriculum materials be the same or different from your experience teaching this mini unit?

Two members of our team interviewed a sample of preservice teachers from each section. For Banks’s and Miller’s sections, the sample was chosen based on all preservice teachers who volunteered. For Jacobs’s section, there was a large enough number of preservice teachers willing to be interviewed, that interviews were chosen to represent a range of proficiency as determined by Jacobs. Interviews took place near the end of the semester and were kept confidential from the instructors. See Table 2 for the sample distribution and analysis procedures.

Ideal Science Statements (Jacobs’s Section)

The Ideal Science Statement assignments given at the beginning and end of the semester asked the preservice teachers to

write a statement that you might provide for a principal who is considering you as a candidate for a teaching position where teaching science and working with the science curriculum will be important roles. [Describe your] current ideas about what elementary school science should be like.

We used the Ideal Science Statements to address Research Question 3, which relates to preservice teachers’ personally derived criteria. See Table 2 for additional sample and analysis details. The responses to the Ideal Science Statements were coded and tabulated to determine the nature and change of qualities of idea science teaching. We present data for the 15 preservice teachers in Jacobs’s section for whom there were both pre- and postinstruction data. We also note that only those categories with 50% or more preservice teachers responding (8 of 37 categories) are discussed in our results.
RESULTS

Knowledge of Criteria and Frameworks Within Structured Tasks (Research Question 1)

Our first research question asked how accurately did preservice teachers apply the criteria within structured curriculum materials analysis tasks where use of the criteria was required. We asked this question to examine the preservice teachers’ capacity to use the Project 2061 Criteria as tools while interacting with curriculum materials. To address this question, we draw on data analyses of preservice teachers’ unit and curriculum materials analysis forms in all sections. Results of these analyses are summarized in Figure 1. This figure illustrates

![Figure 1](image-url)

_**Figure 1.** Mean scores of preservice teachers’ levels of accuracy in applying curriculum materials analysis criteria in all methods sections._

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the average level of preservice teachers’ accuracy in applying the Project 2061 Criteria from their analysis of their units or curriculum materials within each methods section.

Analysis of data across all three sections indicates mixed results in preservice teachers’ application of the criteria while analyzing curriculum materials. As each section used different sets of criteria, there were 26 total instances of preservice teachers’ application of criteria. Of the 26 instances of using the 15 different criteria across course sections, preservice teachers demonstrated a strong level of accuracy in 7 instances, an adequate or moderate level of accuracy in 11 instances, and either a poor level of accuracy or an inaccurate application for 8 instances. Furthermore, while there is variation in accuracy of application of criteria between sections, there are underlying patterns in preservice teachers’ use of several of the criteria that may be useful for determining how to support preservice teachers in learning to use curriculum materials effectively.

**Patterns in Accurate Application of Criteria.** Across the three sections of the course, there were two criteria that the preservice teachers were particularly accurate in applying. Those two criteria are “learning goal” (do the materials address the intended learning goal?) and variations on an inquiry-based criterion (“data into patterns” in Banks’s section, “inquiry” in Miller’s section, and “engaging students with relevant phenomena” in Banks’s and Jacobs’s sections). This pattern mirrors results found by Davis (2006).

In Miller’s and Jacobs’s sections, most preservice teachers were able to evaluate whether an activity matched the stated learning goal. For example, one preservice teacher wrote,

[This curriculum material] does address the learning goal [Animals have unique characteristics that are suitable for living in certain habitats.] . . . By having group discussions, the students share with others what they have learned and together work to find similarities and differences between animals within the same habitat and in different habitats, looking at what challenges each habitat poses that the animals cope with in order to survive.

This outcome was not identical in Banks’s section, where preservice teachers had a wide range of responses (including, for example, sometimes misapplying the criterion by evaluating materials with respect to whether they addressed a particular topic rather than supported achieving a specific learning goal) for reasons that are explored in the interpretation section below.

In Banks’s and Jacobs’s sections, preservice teachers accurately analyzed whether the materials provided opportunity for analysis of “data into patterns” and whether the materials engaged students with “relevant phenomena.” One example of a preservice teacher with an accurate application of the criterion for opportunity for analysis of “data into patterns” is one who explained that in her mini unit, “Students use eating habits to determine whether animals are herbivores, carnivores, omnivores or insectivores and they also look for patterns in the food web with producers, consumers, and decomposers.” This example provides a clear reference to a specific example of analyzing data—what do different animals eat—and looking for patterns.

**Interpretation of Patterns in Accurate Application of Criteria.** These outcomes are interesting for several reasons. We hypothesize that preservice teachers in Miller’s and Jacobs’s sections accurately applied “learning goal” due to these instructors’ explicit attention to this criterion and their systematic use of this criterion in multiple contexts. For example, both instructors asked preservice teachers to “unpack” the learning goals for their materials and determine whether the lessons in their materials helped learners meet the learning goal.

In contrast, Banks’s use of the learning goal criterion was implicit, incorporated multiple components, which may have been distracting for the preservice teachers (e.g., did the
learning goal address science knowledge, practices, and habits of mind), and used the criterion only three times within the course. Furthermore, Banks’s midsemester criteria forms compared to final semester criteria forms indicate that preservice teachers had great difficulty accurately applying “learning goal” when the criterion was first introduced. Large gains in this criterion for Banks’s class (even though the final performance was still adequate rather than strong) may indicate that the meaning behind this criterion became somewhat more accessible, and the goals may have become aligned with the preservice teachers’ own goals with some support and practice during the semester.

We also note that preservice teachers in Banks’s and Jacobs’s sections accurately applied several inquiry criteria “data into patterns” and “engaging students with phenomena” for perhaps similar reasons. Banks’s course provided explicit attention and opportunities for implementation of the first-hand data collection and patterns from data criteria. Those criteria were contextualized within an instructional model, as well as illustrated with demonstration science lessons in which preservice teachers participated. We hypothesize that the accurate application of “data to patterns” along with similar results from inquiry criteria in Jacobs’s and Miller’s sections suggest that the meaning of the criteria became increasingly accessible during the semester, perhaps through systematic practice and experiences. We also note that preservice teachers’ success in appropriating the inquiry criteria may be related to the similarity of these criteria to their own “hands-on” criterion (see outcomes for Research Question 3 and Davis, 2006).

**Patterns in Inaccurate Application of Criteria.** Analysis of the data points toward two criteria that were particularly challenging for preservice teachers to apply accurately when analyzing curriculum materials. Those criteria included “sense of purpose” and “application and practice.” Analysis of comments and examples of “sense of purpose” in Miller’s and Jacobs’s sections suggest the preservice teachers had a tendency to evaluate whether they thought the activities in the curriculum materials themselves were interesting and would capture students’ attention, rather than looking specifically at the purpose presented for each activity and evaluating whether or not that purpose might be motivating to students.

Preservice teachers interpreted the criteria in other ways as well—sometimes as building on previous knowledge or providing a motivating environment. For example, one preservice teacher in Banks’s section responded that her mini unit met the “sense of purpose” criterion in that “it gave [the students] the opportunity to reflect on predictions and work hands on with a small group of peers.” This response does not address whether or not the unit provided a motivating or engaging sense of purpose related to the learning goal for students.

The criterion of “application and practice” was challenging for preservice teachers in Banks’s and Jacobs’s sections. Responses from preservice teachers indicate that they misinterpreted the “application and practice” criteria by considering as evidence of this criterion any task or activity involving real world phenomena at any point in an activity sequence outlined in a curriculum material, rather than as a task or activity that came later in a sequence, where students would apply knowledge or skills that they had learned earlier to a new context. For example, in indicating that her mini unit addressed the application and practice criterion, a preservice teacher in Banks’s section wrote, “the students have already investigated the seeds sprouting and growing into plants.” Responses from preservice teachers in Miller’s section (who accurately applied this criteria) indicates that they were able to interpret and apply the “model, coach, fade” elements of this criterion.

**Interpretation of Patterns Within Inaccurate Application of Criteria.** These outcomes indicate several possible interpretations that support and coincide with those mentioned in
the prior section. We hypothesize that preservice teachers had difficulty accurately applying and using criteria such as “sense of purpose” and “application and practice” because the meaning of criteria was not accessible (e.g., the language was technical, foreign, or dense; the terms were not well aligned with preservice teachers’ vernacular use of those terms). For example, preservice teachers may have interpreted the meaning of “sense of purpose” as providing motivation for students. Similarly, preservice teachers may have interpreted “application and practice” as meaning any practical experiences within an activity sequence, rather than as having opportunities to apply what one has learned to new situations (e.g., during the fade component of a “model, coach, fade” cycle).

There are other patterns in the data that also support the hypothesis that the meanings behind the criteria may not have been accessible for preservice teachers for a variety of reasons. There are several examples of language in the written criteria that were interpreted differently or not understood. For example, one of the components of Miller and Jacobs’s “assessment” criterion asked whether the assessments were designed to “inform” instruction. Preservice teachers interpreted the term to mean that the materials could tell the teacher how to carry out the assessment rather than teachers could effectively use the results of students’ assessment to design their next lessons. For example, one typical response from Miller’s section was “The teacher’s guide is a great source for information and instruction. The steps are given by action verbs, so it is clear what is being asked.” Furthermore, Miller’s nature of science criterion, which referred to the dynamic and social nature of science, was often interpreted as providing opportunities for students to socially construct their own knowledge. A typical response to this criterion in analysis of materials was “Students will actually be scientists, and construct their own knowledge from observing and building an aquarium. They will have first hand experience on constructing knowledge of guppies and snails.” Lack of alignment between the Project 2061 Criteria and preservice teachers’ personal criteria may have made the preservice teachers’ appropriation of the Project 2061 Criteria as tools for using curriculum materials very challenging. Further evidence concerning the preservice teachers’ own criteria is presented in results for Research Question 3.

In summary, it appears that preservice teachers had mixed success in applying the Project 2061 Criteria as intended for analyzing curriculum materials. The weak outcomes for some criteria may be due to difficulty in accessing intended meanings behind the criteria because of inaccessibility of the language (e.g., the terms were not well aligned with preservice teachers’ vernacular use of those terms) and perhaps not enough opportunities for making sense of the meanings of the criteria and for applying the criteria in multiple settings. Furthermore, these outcomes may have been exacerbated by the large number of criteria used within each section and lack of congruence between the Project 2061 Criteria and their own.

Use of Introduced Criteria and Frameworks Within Open-Ended Tasks (Research Question 2)

Our second research question examines how and to what extent preservice teachers chose to apply the introduced criteria when analyzing, planning, or modifying curriculum materials within open-ended tasks where use of the criteria was not required or cued. To address this question, we draw on data analysis from the pre- and post-Light and Shadows Assessments from all sections, audiotaped dialog around those assessments in Banks’s and Miller’s sections, and Jacobs’s Ideal Science Statements and Unit Reflections. More specifically, we use two types of data to address this research question. The first includes the particular criteria preservice teachers’ invoked when analyzing the strengths

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and weaknesses of materials (Light and Shadows Assessment Question 1), justifying their lesson sequences (Light and Shadows Question 3), or referencing qualities of science teaching in the Ideal Science Statements or Unit Reflections). We note that while we do not present every outcome, we report all the criteria with large pre–post changes in use. The second type of data includes researcher judgments about the extent to which the preservice teachers’ planned lesson sequences met the criteria (Light and Shadows Question 2). Figures 2, 3, and 4 show pre–post results for how the preservice teachers’ lesson sequences met the criteria. Because the analyses are detailed and the patterns complex, we refer the reader to our technical document with this information (http://www.msu.edu/~cschwarz). We highlight only the major findings from these analyses in the paragraphs below.

**Patterns in Use of Criteria.** In analyzing the data related to preservice teachers’ use of curriculum materials, we found evidence that preservice teachers used a few criteria similar to Project 2061 Criteria while they analyzed and planned activity sequences. In particular, patterns across sections indicate an increase in focus over the semester on whether the materials addressed the learning goal and whether the materials addressed the inquiry criteria mentioned above (e.g., “data into patterns,” “inquiry,” and “providing experiences”).

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With respect to learning goal, Miller’s preservice teachers increasingly wrote about learning goal as a criterion for determining the strengths and weaknesses of activities in the Light and Shadows Assessment, mentioning it 5 times in the pretest compared to 16 times in the posttest (a change of three to five preservice teachers out of a sample of eight). For example, they considered learning goals in the following dialogue about the strengths and weaknesses of Light and Shadows activities,

Student 1: . . . We should probably, in the future ones, like see if it [the activity] meets the learning goal. We can use that as a strength or weakness.
Student 2: Do we have a learning goal?
Student 3: Yeah.
Student 4: The learning goal is explain how shadows are made. So a weakness for the first one is it doesn’t connect to the learning goal.

Preservice teachers’ lesson sequences in the Light and Shadows Assessment increasingly met the learning goal criterion for both Miller’s section (19% increase in mean rating) and Jacobs’s section (11% increase in mean rating) For example, in Jacobs’s section, one preservice teacher began her lesson sequence with the phrase “Introduce that we are going to find out how and why shadows are made.” Another preservice teacher began her lesson sequence by writing “Intro-give students flashlights and allow them to experiment with shadows they can make with one object, like a pencil (an opaque object). Have a discussion and ask for student ideas about how shadows are made.”

Our analysis of the pre–post differences in preservice teachers’ Light and Shadows Assessments also points to a small increase in preservice teachers attending to various inquiry criteria. For example, preservice teachers in Banks’s section increasingly wrote about “collecting and analyzing data” as a dimension for evaluating the strengths and weaknesses of materials. Preservice teachers in Banks’s section spontaneously analyzed the materials for whether or not they allowed for opportunities to “collect data” 4 times in the pretest compared to 14 times in the posttest (a change from three to seven preservice teachers out of a sample of ten). They also referred to materials providing opportunities for “analyzing data” 4 times in the pretest compared to 12 times in the posttest (a change of three to six preservice teachers in the pre- to post-test) and mentioned this verbally by stating such things as, “[The activity] did help them look for patterns... and explore like the world around them.” Others in Miller’s section increasingly focused on whether the
activities provided children with “experiences”—a change from no references in the pretest compared to 11 times in the posttest (a change from none to five preservice teachers out of a sample of eight).

While this result supports those found in our first research question and results from Davis (2006), we found another noteworthy and promising pattern; preservice teachers increasingly and spontaneously addressed criteria related to the instructional models used within their methods section in designing their Light and Shadows lesson sequences. For example, by the end of the semester, preservice teachers within Banks’s section increasingly focused on data collection and analysis and establishing a welcoming environment for all students—coincident with her section focus on model-centered inquiry within a learning community. Posttest lesson plans in Miller’s section increasingly provided a “sense of purpose” (31% increase in mean rating), “enhanced learning environment for all students” (19% increase in mean rating) and “sequenced activities” (38% increase in mean rating). In other words, their lesson sequences at the end of the semester provided a motivating introduction to the lessons and were more likely to reflect an instructional model or other systematic approach to sequencing. These outcomes coincided with her introduction to instructional models and lesson sequencing as well as a focus on taking into account students’ cultural backgrounds. Finally, Jacobs’s preservice teachers increasingly met criteria related to the conceptual change instructional model. For example, they showed an increase in providing a “sense of purpose” (25%), taking into account “students’ ideas” (17%), and “assessing” students’ ideas (22%). To illustrate, one preservice teacher in Jacobs’s section provided a “sense of purpose” and took into account “students’ ideas” in her lesson sequence by examining what students already know and generating target questions. She wrote, “Explore Shadows. Get feedback on what students discovered (chart?). Generate target questions, what we want to know. (Know what misconceptions need to be addressed). . . ”

We also note, however, that few of the other Project 2061 Criteria were addressed in preservice teachers’ analysis of the strengths and weaknesses of materials or pre–post lesson sequences as detected from our Light and Shadows Assessment. Of particular note was the lack of lesson sequences meeting the criterion of “application and practice.”

Analysis of Jacobs’s Ideal Science Statements lends additional support to findings from the Light and Shadows Assessment that the criteria played a limited role in preservice teachers’ views of effective science teaching. Post-Instructional Ideal Science Statements indicate that half of the preservice teachers mentioned the criteria—“first hand experiences” and “assessment.” Only 15% used more than two criteria and none of the preservice teachers used the criteria as an organizing framework in these essays. However, we note that other conceptual frameworks used in Jacobs’s section, such as the conceptual change instructional model or experiences–patterns–explanations (a model of scientific inquiry; Anderson, 2003), played more prominent roles in the Ideal Science Statements.

Interpretation of Patterns in Use of Criteria. Our results from the second research question support and extend findings from the first research question. Once again, preservice teachers made some use of the learning goal and inquiry criteria within their own materials analysis and lesson-sequences in the Light and Shadows Assessment. As stated before, we hypothesize that the meaning of these criteria may have become accessible during the methods courses, perhaps because of particular experiences using the criteria or some initial or early alignment with preservice teacher’s own criteria (see results for Research Question 3). It also appears that some of the criteria related to instructional models such as “taking into account students ideas” and “sequencing” were appropriated. This may have been due to having opportunities to make sense of and use those criteria within the
instructional model frameworks (in which there were coherent patterns with a structure that preservice teachers could use to design lessons). It remains unclear as to why “application and practice” was particularly poorly appropriated. This outcome may have been due to fewer experiences working with these criteria, an alternative understanding that providing experiences also provides practice, or a problem with the design of the Light and Shadows Assessment itself.

In returning to our framework, these results indicate that the preservice teachers used some of the criteria when analyzing curriculum materials. Nonetheless, it appears that preservice teachers needed greater opportunities to make sense of the complex and perhaps noncommensurate criteria, to engage in using the criteria within various contexts, and to obtain coherent and perhaps useful tools such as instructional models that synthesize the criteria and provide a more coherent and practical plan for their use.

**Preservice Teachers’ Own Criteria for Analyzing Curriculum Materials (Research Question 3)**

Our third research question examines how preservice teachers drew on their personal ideas about science teaching to analyze curriculum material. In other words, aside from the Project 2061 Criteria, how else did they analyze the materials? To address these questions, we draw on data analyses from the pre- and post-Light and Shadows Assessments in all three sections, dialog around those assessments in Banks’ class, Jacobs’s Ideal Science Statements, and analysis of interviews. See Table 4 for a summary of findings.

One of the most striking aspects of this study was the finding that when given directions to evaluate the strengths and weaknesses of materials or to describe important qualities of science teaching, preservice teachers made little spontaneous use of the Project 2061 Analysis Criteria, even though their use had been scaffolded during the structured tasks as an approach for effective science teaching. Rather, they often used their own criteria. While other studies have shown that preservice teachers come to methods courses with strong intuitive ideas (Abell et al., 1998), this study aimed to determine whether the Project 2061 Criteria could provide a tool to mediate reform-based objectives and preservice teachers’ intuitive objectives while they participate with materials.

<table>
<thead>
<tr>
<th>TABLE 4</th>
<th>Preservice Teachers’ Own Criteria for Analyzing Materials and for Describing Ideal Science Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Most Frequent Criteria From All Sections</strong></td>
<td><strong>Most Frequent Criteria From Banks’s Section</strong></td>
</tr>
<tr>
<td>Combined</td>
<td>Practicality (pre and post) Providing explanations (pre and post) Clarity (pre) Background information (post) Material procedure (post)</td>
</tr>
</tbody>
</table>

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Our data from the Light and Shadows Assessment show that preservice teachers paid a significant amount of attention to dimensions not included in the analysis criteria. For example, in both the pretest and posttest, the most frequent analysis dimension across all three sections involved “practicality” of the activities (18 of 27 or 67% of preservice teachers in the pretest compared to 15 or 56% in the posttest.) The second most frequent dimension was “providing explanations” within the activities—this refers to whether or not the preservice teachers believed that students were provided with an adequate explanation of the phenomena within the activity (14 of 27 or 52% of preservice teachers in the pretest and the posttest). In the pretest of the Light and Shadows Assessment, preservice teachers across all three sections were also greatly focused on “clarity” of the materials or whether the activity would be clear for helping students understand ideas (16 of 27 or 60% of preservice teachers). On the posttest, they were concerned about the “background information” for teachers (13 of 27 or 48% of preservice teachers) and the “materials and procedures” (13 of 27 or 48% of preservice teachers). We found evidence of other dimensions important to preservice teachers within the particular methods sections. For example, preservice teachers in Banks’s section focused on whether or not the materials were “teacher versus student guided.”

To understand more generally how preservice teachers’ lesson sequences might have been affected by their use of the criteria, we analyzed the nature of preservice teachers’ lesson sequencing in the Light and Shadows Assessments. We found the preservice teachers across all three sections tended to adopt a “verification lab” approach in their Light and Shadows Pre-Assessment. In other words, they designed lesson sequences that began by providing students with information or scientific ideas and then moved to having students “verify” the scientific ideas through hands-on activities (14 of 27 or 52% of preservice teachers). Posttest analysis indicates that many preservice teachers moved away from verification lab approach (reduced to 7 of 27 or 26%). For example, preservice teachers in Miller’s section designed sequences that among other aspects began with a purposeful, motivating introduction to the lesson directly linked to the learning goal. Others in Jacobs’s section included an “investigate” activity to preassess and challenge students’ misconceptions. In Banks’s section, they designed sequences that helped students test their ideas or find patterns in data. These lessons sequences more closely aligned with conceptual change and inquiry approaches. This change suggests that the preservice teachers’ learned and used course ideas including some Project 2061 Criteria and the conceptual change or “five E” instructional models.

Further evidence of preservice teachers’ own criteria or qualities for good science teaching emerged from analysis of the Ideal Science Statements in Jacobs’s section. In looking at Table 5, we find that many of the preservice teachers’ emergent qualities from the pre-instruction statements are still present in their postinstruction Ideal Science Statements and are different in nature from the Project 2061 Criteria introduced in class.

The Ideal Science Statements analysis indicates that a number of preservice teachers expressed the goals of making science fun and having a supportive learning environment. Another set of qualities involved the students’ relationship with science. Preservice teachers described how students should be led to see that science is all around them, and it should be related and applicable to their everyday lives and be accessible. Another set of qualities relates to use of resources including taking many field trips and having literature and other resources in the classroom. The last group of emergent qualities relates to teaching approaches. By far the most common approach on the preinstruction statements was doing “hands-on” activities and experiments. This decreased by half on the poststatements, due in large part to their linking the hands-on activities to specific learning goals. In other words, preservice teachers’ references to hands-on activities related to specific learning goals were
TABLE 5
Emergent Qualities\(^{a}\) of Ideal Science from Jacobs’s Section

<table>
<thead>
<tr>
<th>Quality</th>
<th>Pre %(^{b}) (N = 15)</th>
<th>Post % (N = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affective goals and qualities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal: Make science fun</td>
<td>47</td>
<td>53</td>
</tr>
<tr>
<td>Supportive environment</td>
<td>53</td>
<td>40</td>
</tr>
<tr>
<td>Relating students and science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>See science as all around</td>
<td>67</td>
<td>73</td>
</tr>
<tr>
<td>Relate science to everyday life</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td>Make science applicable</td>
<td>53</td>
<td>60</td>
</tr>
<tr>
<td>Using resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take field trips</td>
<td>80</td>
<td>53</td>
</tr>
<tr>
<td>Lots of literature/resources</td>
<td>60</td>
<td>53</td>
</tr>
<tr>
<td>Teaching approaches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do hands on/experiments</td>
<td>60</td>
<td>27</td>
</tr>
</tbody>
</table>

\(^{a}\)Only categories with 50% or greater frequency were included (8 of 37).

\(^{b}\)Percentage of preservice teachers who included quality in statement.

coded as “experiences with phenomena.” In contrast, unspecified or generic references to hands-on activities were coded as “hands-on.” Smaller percentages of preservice teachers mentioned discussions and demonstrations.

Overall, the emergent qualities in the Ideal Science Statements reflect a strong affective component of concern for students. Science should be related to the students’ world and lives. The preservice teachers saw resources in the classroom and community as important. There was little specific mention of science curriculum materials. There was limited reference to specific teaching approaches, although use of a variety of approaches was seen as important.

The interviews also provide some evidence that preservice teachers prefer to analyze and modify curriculum using their own criteria and emphases. A belief that the task of curriculum evaluation will flow from personal teacher preference is expressed by the preservice teacher who states,

> I think a lot of it is just going to come from your knowledge of what you want to do rather than looking or filling out each of those . . . [analysis forms] for every lesson you want to teach.

In summary, it appears that preservice teachers were primarily focused on practical or affective aspects in relation to curriculum materials—ease and logistics of implementation as well as the presence of explanations, background information, and material procedures. In addition, Jacobs’s Ideal Science Statements reflect the preservice teachers’ strongly held desires of making science fun and relevant to everyday life.

The majority of these practical and affective criteria do not overlap with the Project 2061 Criteria. There are a few exceptions. Preservice teachers’ “hands-on” activities criteria relates to Project 2061’s “providing relevant real world examples/phenomena,” though preservice teacher’s often view “hands-on” activities as a strategy for making science fun, motivating children, or illustrating ideas, rather than as a foundation for understanding the learning goals. The Project 2061 Criterion of “sense of purpose” could also potentially overlap with preservice teachers’ goals for motivating students, though the Project 2061 Criterion is specifically aimed at the learning goal, not at general student motivation and
interest. Finally, the Project 2061 Criterion of “welcoming all students” could be related to preservice teachers’ goals of making science fun and related to everyday life, though the emphasis of the Project 2061 Criterion is on learning community that provides high expectations around the subject matter and a sense of belonging within the classroom with respect to the science content. We note that none of the other Project 2061 Criteria, including “building on students ideas,” “developing and using scientific ideas,” “promoting student thinking about experiences,” and “assessing student progress,” are foregrounded in preservice teachers’ own goals or criteria.

Furthermore, the emphasis on detailed analysis of curriculum materials, instructional approaches, and instructional models addressed in the course represents a very different perspective of quality science instruction compared with the perspectives of the preservice teachers. As the Project 2061 Criteria were tools that had limited capability for helping preservice teachers address their own criteria and goals when interacting with curriculum materials, it is not surprising that there was limited uptake in their use when analyzing and designing lesson sequences. Again, we hypothesize that those tools became increasingly helpful when preservice teachers were given multiple opportunities to construct and practice their use in ways that could meet multiple goals (preservice teachers’ and instructors’) and within more coherent, useful frameworks (instructional models or planning sequences) for preservice teachers. Such an approach may enable more effective reform-oriented interactions with curriculum materials.

Attitudes Expressed Toward the Criteria and Curriculum Materials Analysis (Research Question 4)

Our final research question examines general attitudes preservice teachers expressed toward the criteria and the curriculum materials analysis as well as specific perceptions of the criteria and materials analysis. To address these questions, we draw on data from the interviews as well as spontaneous comments provided by preservice teachers in the methods sections. Detailed analysis of transcripts and written summaries of cases can be provided upon request.

Primarily Negative Reactions. We found evidence that the majority of the preservice teachers interviewed (six of eight) expressed a negative attitude toward the analysis criteria and their use within the methods course. We also note, however, that this result may have been due to a large sampling of interviewees (seven or eight) from the two methods sections that used multiple structured curriculum analysis forms throughout the semester. Overall, these preservice teachers found the curriculum analysis in the methods class to be tedious, “frustrating,” “silly,” “time consuming,” “overwhelming,” “too detailed,” or “something we had to do because we were in class.” Further analysis of interview data also indicates that preservice teachers also did not find the analysis particularly useful or well connected to the reality of the classroom.

For example, six of eight preservice teachers commented on their frustration with the detailed and time-consuming nature of the curriculum analysis. One preservice teacher stated,

There was just like, so many parts and it was broken down into so many, many, many, many things. . . . I couldn’t tell you what those [Project 2061] things mean. I understood parts of it—but it just got to a point where there was so many different criteria to use, and I can’t work that broken—down and meticulous and specific. . . . Some of ‘em were just repetitive and monotonous and . . . I don’t know. . . really, like, the purpose of them.
Another stated,

Well, hoops, that is kinda how I felt about it, I’m jumping through hoops, and probably if I were to really give it some thought, the criterion probably could be a really good way of assessing a curriculum, I think that that might be an excellent idea except for given the context with which we used it and where we used it and the time in my schooling, it was just more work. It wasn’t something I went, “Oh yeah, let’s use this.” (laughing).

Preservice teachers varied in their opinions about the utility of the criteria, though most thought the analysis itself was not particularly useful (six of eight). Some were decidedly negative, stating “I didn’t look at them when I planned my unit. Not at all; not once. . . looking at it that detailed, it seemed to take away the whole purpose of the lesson for me.” Others were more neutral—realizing their potential for selecting materials (as the preservice teacher stated above when she mentioned that it could be a good way of assessing a curriculum), but not using them for their own lesson planning. Others simply said, “I felt like the criteria . . . just didn’t enhance anything that we were doing.” “I don’t know if I really used the criteria much in, like, planning my lesson or anything. I just didn’t.”

On the other hand, two of the eight preservice teachers interviewed saw the potential benefit of the criteria analysis in that “it gives you a good outline, you know, to remember, like, “Oh, did I consider this?” and the criteria “give you a rubric to look through things, you know, tell you what you should be looking for in your lessons.” The latter preservice teacher also stated,

As long as I’m aware of the deficiencies the curriculum materials have according to the criterion [sic] and I make the necessary changes in my own lessons, then the materials could be helpful in setting an outline to meet the learning goals.

These statements coincide with another preservice teacher in a different course section who mentioned that while he could not remember all of the criteria, he used them in evaluating the curriculum materials in his placement site and they helped him understand how the curriculum materials were beneficial to the children.

Preservice teachers also found the criteria and curriculum analysis disconnected from the reality of the classroom (five of eight). One stated, “I’ve been in the classroom myself, . . . [and] you will never have time to look at all these things when you are planning the lesson.” Another preservice teacher stated,

I found my lesson was pretty good. And the kids liked it. And my [collaborating teacher] had no complaints. Like she had suggestions, like for next time and stuff, but nothing complaints like. . . it was horrible or anything. But my lesson. . . probably about 30% of it didn’t fit the criteria.

Reasons for Negative Reactions. Interview analysis indicates several reasons why preservice teachers found the criteria and analysis tasks tedious, not useful, and disconnected from the reality of the classroom. Interview data indicate that some preservice teachers had no curriculum materials to evaluate from their school placement sites. These preservice teachers were understandably frustrated at needing to spend time analyzing materials that for them did not exist. One preservice teacher in this situation commented, “We were kind of frustrated because I didn’t have a materials guide so it didn’t even apply to mine.”

Similarly, some preservice teachers who thought they needed to teach the materials exactly as the curriculum dictated because of their cooperating teacher felt that analysis
and modification were inconsequential given that they would have to teach the materials as written anyway. One preservice teacher stated, “We just didn’t know if we strayed from what we were supposed to be doing what our teacher would think about it.” Another stated, “[She] pretty much wanted us to follow . . . what that book said. So I, we really didn’t have a lot of . . . options to develop it outside of it, I guess.”

Another important factor was that most, if not all, of the preservice teachers saw no evidence of curriculum analysis and planning conducted by their cooperating teachers, and as a result, thought that the introduced approaches to curriculum analysis and modification were inauthentic and irrelevant (Gunckel & Tsurusaki, 2006). One preservice teacher stated, “I think it would really help if the criteria was [sic] something implemented by the [cooperating teachers] so that you could see how it would be useful.” Ironically, this preservice teacher’s cooperating classroom teacher was instrumental in using the Project 2061 Criteria for adopting curriculum materials in her district.

As with our other data, these data indicate that for the most part, the criteria did not coincide with preservice teachers’ main goals and concerns in teaching (Abell et al., 1998; Davis et al., 2006). Those goals mentioned in the interviews included: making science fun and engaging, gathering techniques for classroom management, providing hands-on experiences, connecting materials to students’ lives, integrating science with other subjects, and “mass producing lessons.”

Furthermore, we saw some evidence of a contrasting approach for choosing and modifying curriculum materials. Some preservice teachers view the curriculum materials analysis process as overly cumbersome because a teacher “just knows” what will work perhaps because of their implicit and intuitive notions of good materials. In other words, the practice is a more holistic one that depends on a teacher’s intuition. For example, one preservice teacher stated, “I think a lot of it is just gonna come from your knowledge of what . . . you wanna do rather than looking or filling out each of those things for every lesson you wanna teach.” Later, she also stated, “Some things are obvious because you know, like—I’ve—as a teacher, you know what you think is important and you know how you wanna, um . . . what are the different things you wanna incorporate in your science lessons.”

In addition, the detailed nature of the criteria and analysis tasks (which did not coincide well with their own criteria or analysis practices) and the large number of criteria introduced in the sections made it difficult for preservice teachers to comprehend an overall vision for good curriculum materials and effective science teaching (Hammerness, 2001). In other words, there were so many criteria to comprehend and connect, that preservice teachers struggled with understanding and creating a coherent vision for this kind of reform-based teaching.

Finally, we found some evidence that the practice of curriculum materials analysis may have felt destabilizing for preservice teachers (Gunckel & Tsurusaki, 2006). For example, the majority of preservice teachers in one section reacted negatively to the curriculum analysis one day when, during class, they found a published material to be deficient with respect to many of the criteria. One preservice teacher asked, “What is the purpose of saying everything is ‘no’? [In other words, it does not meet the criteria.]” Another preservice teacher further summarized the feelings of many of her classmates by stating, “We think it is a good curriculum and we would want to use it [no matter what the criteria indicate!]”

This statement may indicate several issues. These preservice teachers may have reacted negatively because the criteria did not take their primary goals and concerns into account. In addition, these preservice teachers may have forcefully rejected the outcome of the curriculum analysis because they lacked confidence about their subject matter knowledge and were concerned about how they might teach science without curriculum materials (Gunckel & Tsurusaki, 2006). As such, this reaction may have indicated a greater need in
the methods course for developing knowledge and skills to modify materials to address weaknesses.

The outcomes from the interviews indicate a broad range of factors at play in preservice teachers’ interactions with curriculum materials. In particular, they highlight preservice teachers’ beliefs, criteria and goals, the holistic nature of their interaction with materials, as well as their participation in multiple communities of practice with potentially conflicting norms of effective science teaching and productive interactions with curriculum materials. These statements also highlight the nature of preservice teachers’ status in those communities when participating with materials. These broader factors are central to better understanding and supporting preservice teachers’ reform-based interactions with materials.

SUMMARY AND INTERPRETATION OF RESULTS

Our overall questions addressed how preservice teachers can be supported in developing their professional knowledge and practices for analyzing and modifying curriculum materials. We found that preservice teachers had mixed success using the Project 2061 Criteria for analyzing curriculum materials as a result of our approach. They were most successful at accurately and spontaneously applying criteria related to learning goal and inquiry. Furthermore, the meaning of these criteria became more accessible to the preservice teachers over the duration of the course. They were least successful at accurately and spontaneously applying other criteria such as “sense of purpose” or “application and practice,” whose meanings they had difficulty accessing throughout the course duration.

We also found that preservice teachers used many of their own rather than reform-based criteria for analyzing the strengths and weaknesses of materials. Furthermore, these practical and affective criteria and goals did not overlap with many of the reform-based Project 2061 Criteria. Finally, our analysis indicated that preservice teachers viewed the curriculum analysis procedure as too detailed and unhelpful for meeting their future teaching goals. This analytical process also contrasted with their intuitive and holistic view of their future participation with curriculum materials—that a good teacher “just knows” what are good materials.

We found several underlying reasons for these outcomes that are important for successfully helping preservice teachers learn to use curriculum materials for effective science teaching. It is important to note that for any one criterion or any one preservice teacher, a combination of these reasons most likely contributed to the accessibility of the intended meanings of the criteria. First, the intended meanings of many of the criteria were implicit or hidden in language that also held different vernacular meanings for the preservice teachers. The preservice teachers were better able to access the intended meanings of criteria when those intended meanings were closely aligned with the preservice teachers’ vernacular interpretations of the criteria. Subsequently, these criteria were also more likely to be taken up and appropriately used by the preservice teachers in both structured and open-ended course tasks.

Second, preservice teachers were more likely to appropriate the reform-based criteria when those criteria aligned with their own goals and criteria. For example, we hypothesize that for some preservice teachers, the inquiry criteria, with their focus on providing experiences, may have aligned with the preservice teachers’ concern for providing hands-on activities for student learning. Because the preservice teachers were able to connect their own goals with the inquiry criteria, these criteria may have served as a bridging scaffold for helping preservice teachers incorporate inquiry principles into their analysis and use of curriculum materials. However, we note that, for the most part, our approach using the criteria did not adequately help preservice teachers expand beyond many of their intuitive
goals and criteria. Nor did it adequately enable them to see how the criteria and analysis we introduced could help them meet their own objectives.

Third, preservice teachers were more likely to accurately appropriate and apply criteria when they had opportunities to unpack the intended, and often implicit, meanings of the criteria, and connect them to organizing structures or frameworks such as instructional models. Organizing structures and frameworks may have been particularly important given the large number or criteria used within each section, making it difficult for the preservice teachers to comprehend a cogent framework or vision behind the criteria.

Fourth, we interpreted the differences between the preservice teachers’ goals and the goals embodied in the Project 2061 Analysis Criteria as well as the differences in views of authentic practice as evidence that preservice teachers were navigating among different communities of practice. These communities included their classroom placements in the schools, methods courses, and science courses. Each of these communities holds different and sometimes conflicting norms and values about curriculum use and teaching practice. As a result, they had different views of authentic practice and expectations about the role of curriculum materials in that practice. They did not see the analytical curriculum materials practice visible in their field classroom and sometimes felt that they were not in a position to alter the materials that their collaborating teacher wanted them to use.

Finally, preservice teachers may have found the process of curriculum analysis, which uncovered inadequacies of curriculum materials, destabilizing to their future teaching practice (Gunckel & Tsurusaki, 2006). Given that curriculum materials analysis is challenging and tends to highlight their beginning levels of subject-matter knowledge and pedagogical content knowledge, as well as potential problems with curriculum materials, preservice teachers may have realized that in addition to not being able to rely on themselves for teaching the lessons, they would not be able to rely on the curriculum materials either.

These findings suggest new and important factors that should be incorporated into a theoretical framework of teachers’ participation with curriculum materials (Remillard, 2005). In particular, our findings add the role of tools in scaffolding or mediating preservice teachers’ interactions with curriculum materials. Our findings also highlight the role of preservice teachers’ criteria, goals, and holistic interactions with materials as well as preservice teachers’ envisioned beliefs about their future teaching practice (including their vision of the role of curriculum materials and their relationship with those materials). Finally, our findings add important information about the contexts of preservice teachers’ participation with materials. Preservice teachers participate in multiple communities of practice that hold potentially conflicting values and norms associated with curriculum materials and science teaching. These values and norms as well as the nature of preservice teachers’ status within these communities impact their participation with materials.

IMPLICATIONS AND CURRENT DIRECTIONS

It is essential to help preservice teachers learn to participate productively with curriculum materials. When these teacher candidates begin teaching, such knowledge and practices will enable them to use curriculum materials more effectively to support student learning. This study has focused on the use of Project 2061 Instructional Analysis Criteria as tools to scaffold development of an analytical stance toward curriculum materials and a reform-vision for teaching science in elementary preservice teachers. Just as curriculum materials are tools for building the planned curriculum and what teachers bring mediates how they use curriculum materials tools (Remillard, 2005), what preservice teachers bring to using the Instructional Analysis Criteria (their own analysis criteria and goals for teaching), and the communities in which they participate, mediate their development of an analytical stance.
toward curriculum materials and their use of the criteria to analyze materials. Similarly, what the tools provide depends on how preservice teachers use the tools and how well the tools scaffold practice.

Overall, we learned that there are substantial challenges associated with helping preservice teachers develop reform-based analytical stances toward participating with curriculum materials. One prominent example is that preservice teachers often hold an intuitive and holistic rather than an analytical or criterion-based approach to participating with materials. Given such challenges, however, we also learned that some contexts and approaches for scaffolding analytical tool use can help preservice teachers broaden their practices to include a more reform-based, analytical stance. In order for science teaching tools such as the Project 2061 Criteria to be effective in scaffolding preservice teachers’ analytical stance toward using curriculum materials, the tools must have intended meanings that are accessible to preservice teachers. Curriculum materials analysis criteria should leverage preservice teachers’ own goals for teaching and using curriculum materials and seem relevant to preservice teachers’ visions of their future practice. Preservice teachers should have opportunities to unpack the intended meanings of analysis criteria through engagement in their use. Furthermore, the criteria must fit together into a coherent, overarching framework. Finally, the tools and their use should make the intended practices visible and expedient rather than hidden or destabilizing as preservice teachers navigate among multiple communities of practice.

From these lessons, we have redesigned our approach and are analyzing a subsequent round of implementation in methods courses. Central to our new approach is incorporation of the analysis criteria into an explicit instructional model that both connects to aspects of preservice teachers’ own criteria and encourages them to consider new aspects of reform-based planning and teaching (Gunckel et al., 2007). Furthermore, we have designed several more tasks similar to the Light and Shadows Assessment that provide authentic and productive contexts for analyzing curriculum materials (Schwarz, Covitt, Bae, Mikeska, & Paluta, 2007). Finally, our team has been working with cooperating teachers to make curriculum materials use in the field placement more explicit, visible, and aligned with methods course goals.

Work in understanding and developing teachers’ knowledge and practices using curriculum materials as well as in helping them form productive visions and intentions around using curriculum materials is critical for student learning. The work reported here helps clarify what teachers should know and be able to do with curriculum materials. Preservice teachers need to understand that curriculum analysis and modification is central to their future teaching practice, develop their beginning knowledge and practices for productively using materials, and reconcile their intuitive and reform-based principles so that they may consider both in a systematic way. This work has highlighted important features of tools, their use, and the contexts of their use for scaffolding preservice teachers in developing an analytical stance toward using curriculum materials and knowledge and practices for analyzing and modifying materials in reform-based ways. Given the ever-present goal of effectively advancing student science learning, our field needs to continue working to create and refine science teacher education approaches that will promote high levels of knowledge and practice in using curriculum materials.

We thank all of the members of the Elementary Teachers and Curriculum Materials research group for their help in analyzing and interpreting the outcomes presented in this paper. We are also grateful for the support from the NSF sponsored Center for Curriculum Materials in Science that enabled us to conduct this work. Finally, we thank the preservice teachers who generously participated in this study.
APPENDIX A

Banks’s Criteria

Banks’s Curriculum Materials Analysis Criteria

A. Do the materials/lessons address the learning goal? (Is the learning goal science? Does it address science content, practices (inquiry), and/or habits of mind?)
B. Do the materials/lessons convey an overall sense of purpose and direction that is motivating and relates to students’ interests and sense of importance and relevance? (Project 2061 category 1)
C. Do the materials/lessons take into account students’ ideas and build on students’ understanding? (Project 2061 category 2)
D. Do the materials/lessons provide an opportunity to engage with relevant phenomena, with high priority to first hand data collection and other kinds of experiences and observations? (Project 2061 modified category 3)
E. Do the materials/lessons provide an opportunity for analysis of those data or experiences into patterns?
F. Do the materials/lessons provide opportunities to create explanations or models from those patterns and compare those explanations and models with those from others and from the scientific community? (Project 2061 modified category 5A)
G. Do the materials/lessons provide opportunities for application and practice using explanations and models? (Project 2061 category 4F)
H. Do the materials/lessons provide opportunities for assessing student progress and learning throughout the lessons? (Project 2061 category 6)
I. Do the materials/lessons provide opportunities for fostering habits of mind as well as establishing an environment that welcomes and encourages all students? (Project 2061 category 7)

Miller’s Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Learning goal match</td>
<td>Does the material address the intended learning goal?</td>
</tr>
<tr>
<td>IA Establishing a purpose</td>
<td>Does the material convey an overall sense of purpose?</td>
</tr>
<tr>
<td>IC Sequencing of activities</td>
<td>Does the material involve students in a sequence of activities that systematically build toward understanding of the learning goal?</td>
</tr>
<tr>
<td>II Building on student ideas</td>
<td>Does the material take account of and build on student ideas?</td>
</tr>
<tr>
<td>Inquiry</td>
<td>Does the material provide experiences with phenomena, opportunities to look for patterns in data, and develop explanations from evidence?</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Criteria</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of science</td>
<td>Does the material help students understand the dynamic nature of science knowledge or the social nature of knowledge construction?</td>
</tr>
<tr>
<td>IVF Providing practice</td>
<td>Does the material provide questions and/or tasks for students to practice using knowledge or skills related to the learning goal?</td>
</tr>
<tr>
<td>V Promoting student thinking</td>
<td>Does the material promote student thinking about experiences and knowledge?</td>
</tr>
<tr>
<td>VI Effective assessment</td>
<td>Does the material provide opportunities to assess student progress toward the learning goals?</td>
</tr>
<tr>
<td>VIIC Inclusiveness</td>
<td>Does the material help to create a classroom community that is reflective of and welcoming to all students?</td>
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</tbody>
</table>

### Jacobs's Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Explanation</th>
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</thead>
<tbody>
<tr>
<td>0 Learning goal match</td>
<td>Does the material address the intended learning goal?</td>
</tr>
<tr>
<td>IA Establishing a purpose</td>
<td>Does the material convey an overall sense of purpose?</td>
</tr>
<tr>
<td>II Building on student ideas</td>
<td>Does the material take account of and build on student ideas?</td>
</tr>
<tr>
<td>III Engaging students with phenomena</td>
<td>Does the material provide multiple and varied phenomena to support the learning?</td>
</tr>
<tr>
<td>IVF Providing practice</td>
<td>Does the material provide questions and/or tasks for students to practice using knowledge or skills related to the learning goal?</td>
</tr>
<tr>
<td>V Promoting student thinking</td>
<td>Does the material promote student thinking about experiences and knowledge?</td>
</tr>
<tr>
<td>VI Effective assessment</td>
<td>Does the material provide opportunities to assess student progress toward the learning goals?</td>
</tr>
</tbody>
</table>

**APPENDIX B: EXAMPLE UNIT MATERIALS ANALYSIS FORM FROM BANKS’S SECTION (FIRST PAGE ONLY)**

Learning goals:
- Michigan Curriculum Framework Constructing Benchmarks:
- Michigan Curriculum Framework Using Benchmarks:

*Science Education*
### Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Meets (Yes) or Doesn’t Meet (No)</th>
<th>Citations: Give examples that show how the material meets the criterion or explain why it does not meet the criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Do the materials/lessons address the learning goal? (Is the learning goal science? Does it address science content, practices (inquiry), and/or habits of mind?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Do the materials/lessons convey an overall sense of purpose and direction that is motivating and relates to students’ interests and sense of importance and relevance? (Project 2061 category 1)</td>
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<tr>
<td>C. Do the materials/lessons take into account students’ ideas and build on students understanding? (Project 2061 category 2)</td>
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<tr>
<td>D. Do the materials/lessons provide an opportunity to engage with relevant phenomena, with high priority to first hand data collection and other kinds of experiences and observations? (Project 2061 modified category 3)</td>
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</tr>
<tr>
<td>E. Do the materials/lessons provide an opportunity for analysis of those data or experiences into patterns?</td>
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### APPENDIX C: EXAMPLE CURRICULUM MATERIALS ANALYSIS FORM FROM MILLER’S AND JACOBS’S SECTIONS

**Criterion IVF: Providing Practice**

**Name of Material:**

**Learning Goal:**

What are the students supposed to KNOW?

What are the students supposed to DO?

**Criterion IVF: Providing Practice**

Does the material provide questions and/or tasks in a variety of situations for students to practice knowledge or skills related to the learning goal?

<table>
<thead>
<tr>
<th>Meets (Yes) or Doesn’t Meet (No)</th>
<th>Citations: Give examples that show how the material meets the criterion or explain why it does not meet the criterion</th>
<th>How could you modify the activity if you were to teach it to make up for its deficiencies?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice. Does the material include questions or tasks for students to practice using knowledge or skills related to the learning goal?</td>
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<table>
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<tr>
<th><strong>Contexts.</strong> Does the material provide practice using unfamiliar contexts as well as familiar ones?</th>
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<tr>
<th><strong>Model, Coach, Fade.</strong> Does the material provide students with opportunities for guided practice with feedback and then with practice which gradually decreases the amount of support? (Model, Coach, Fade)</th>
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<tr>
<th><strong>Connecting to Students.</strong> Does the material provide practice opportunities that my students will find relevant and comprehensible?</th>
<th></th>
</tr>
</thead>
</table>

REFERENCES


Brown, M. W., & Edelson, D. (2003). Teaching as design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice? Evanston, IL: Center for Learning & Technology in Urban Schools, Northwestern University.


Science Education


