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Studies of teachers' use of mathematics curriculum materials are particularly timely given the current availability of reform-inspired curriculum materials and the increasingly widespread practice of mandating the use of a single curriculum to regulate mathematics teaching. A review of the research on mathematics curriculum use over the last 25 years reveals significant variation in findings and in theoretical foundations. The aim of this review is to examine the ways that central constructs of this body of research—such as curriculum use, teaching, and curriculum materials—are conceptualized and to consider the impact of various conceptualizations on knowledge in the field. Drawing on the literature, the author offers a framework for characterizing and studying teachers' interactions with curriculum materials.

KEYWORDS: curriculum materials, curriculum use, mathematics, teaching, textbooks.

At present, mathematics education finds itself at the intersection of two distinct trends in relation to curriculum and curriculum programs. The first trend is the availability of newly designed curriculum materials accompanied by research on their implementation (e.g., Riordan & Noyce, 2001; Senk & Thompson, 2003; National Research Council, 2004). Developed by mathematics educators with funding from the National Science Foundation, these curriculum materials were designed to support the curriculum standards published by the National Council of Teachers of Mathematics (NCTM) in 1989 (*Curriculum and Evaluation Standards for School Mathematics;* hereinafter, *Standards*). Like the NCTM *Standards,* these curricula emphasize mathematical thinking and reasoning, conceptual understanding, and problem solving in realistic contexts. Consequently, they require the teacher to play a substantially different role in the mathematics classroom than has been typical among teachers in the United States. The second trend is the tendency for school districts to regulate mathematics teaching practices by mandating the use of a single curriculum. Such efforts toward regulation have been initiated largely in response to the failure of schools to raise student achievement levels, particularly for students of color and from low-income communities, and have been intensified by increased accountability measures taken at all levels of the education system.

As these two trends converge, they result in considerable emphasis on the widespread adoption of new curriculum materials as the primary strategy for improving mathematics education. In most cases, however, the curriculum materials being

adopted are foreign in form and content to most teachers because they are designed to promote reform in school mathematics.

Many educators and researchers find the emphasis on published curricula as means to promote improvement in teaching reminiscent of the curriculum reforms that took place during the late 1950s and early 1960s. During that period, content experts (primarily mathematicians and scientists) sought to improve instruction by designing innovative curricula for teachers to use. These reform efforts failed to take hold in the United States for a number of reasons. However, the failure of reformers to appreciate the central role of the teacher in classroom practices or to anticipate the power of teachers to misinterpret, subvert, and even ignore unfamiliar curricula is often cited as the primary explanation for their demise (Berman & McLaughlin, 1978; Sarason, 1982; Stake & Easley, 1978).

The similarities between the current reforms in mathematics education and those of the "New Math"[1] era provoke pertinent questions about whether present-day reformers and curriculum developers have learned from the mistakes of the past. A number of scholars over the last 25 years have studied how teachers use curriculum materials and the role that textbooks and curriculum materials have played in mathematics classrooms. Although these studies offer insights into the influences underlying curriculum use, as a set, they provide little clarity on *how* teachers use curricula or on the teacher–curriculum relationship. The same studies suggest that understanding curriculum use is not a straightforward proposition. Instead, the teacher–curriculum relationship is intertwined with other teaching practices, is dependent on the particular teacher and curriculum, and is situated in a specified context.

Findings from these studies, however, have not been consolidated to produce reliable, theoretically grounded knowledge on teachers' interactions with curriculum materials that might guide future research or the design or implementation of curricula. The absence of such a synthesis may be due, in part, to the remarkable variation in findings on how teachers use both mainstream and innovative curricula.[2] Some studies, for example, demonstrate that teachers do not follow curriculum guides closely, whereas others suggest close adherence. Studies of teachers using innovative curricula offer instances of teachers rejecting and subverting recommendations in their guides as well as instances of teachers wholeheartedly embracing them.

The analysis presented in this article emerged from a review of the research on teachers' use of mathematics curriculum materials. "Curriculum use" refers to how individual teachers interact with, draw on, refer to, and are influenced by material resources designed to guide instruction. This definition and the discussion that follows rest on the assumption that curriculum use involves an interaction between the teacher and the materials.

My primary assertion—that the current body of literature rests on underdeveloped theoretical ground—grew out of the finding that fundamental constructs such as "curriculum" and "curriculum use" have not been well conceptualized and are framed differently across studies. Thus my aim is to clarify what is understood about this complex interaction and to indicate where more work is needed. I focus my analysis and discussion on underlying conceptual issues that I argue must be addressed to improve knowledge of the teacher–curriculum relationship. As a result, I do not offer an extensive review of several related bodies of literature.

Indeed, a growing number of studies offer insights on how teachers use innovative or *Standards*-based curricula and the cognitive and contextual factors that influence their use. In addition, several studies have examined the ways these resources influence teachers and teaching. The field would benefit from reviews of these bodies of work. Furthermore, these literatures have influenced the focus and analysis in this article. However, my analysis in this article is foundational in nature and lays the groundwork for such syntheses as well as for further research.

First, I examine the literature on curriculum use, focusing on the different ways that curriculum use is conceptualized. In so doing, I identify the constructions of curriculum materials, teachers, and the teaching–curriculum relationship implicit in these conceptualizations, as well as their underlying theoretical influences. I assert that contrasting conceptions of curriculum use taken up in this literature compromise what we can learn about teachers' use of mathematics curriculum materials across studies. I then consider what research on teaching and curriculum can contribute to how curriculum use might be conceptualized. Beginning with the section on teaching, I discuss conceptions of teaching—as a process of design and as multifaceted—that have figured significantly in studies of curriculum use. I also discuss findings from studies that identify individual teacher characteristics that influence curriculum use. I then turn to discussion of curriculum materials and describe ways that curriculum resources have been framed and analyzed in studies of curriculum use. In the final sections of the article, I draw these two components of the teacher–curriculum relationship together in a framework that represents the dimensions of this relationship, and I highlight areas where more empirical and conceptual work is needed.

Distinguishing Between the Intended and Enacted Curricula

Throughout this article, I use the terms "curriculum materials," "curriculum," and occasionally "textbook" to refer to printed, often published resources designed for use by teachers and students during instruction. Over the years, these resources have varied in focus, style, philosophy, and degree of comprehensiveness and have taken on various roles in the minds of educators and policymakers. I discuss these trends in greater detail later. Here, I acknowledge that the term "curriculum" has multiple meanings. It is used to refer to overarching frameworks that specify what should be taught or to guides or other resources that teachers use when designing instruction and deciding what will be enacted in the classroom. For clarity, I use the term only to refer to the resources and guides used by teachers.

Curriculum theorists distinguish among meanings by delineating categories to describe each type of curriculum. "Formal curriculum" (Gehrke, Knapp, & Sirotnik, 1992), for example, refer to the goals and activities outlined by school policies or designed in textbooks. "Intended curriculum" refers to teachers' aims, whereas "enacted" or "experienced" curriculum is what actually takes place in the classroom (Gehrke et al.). The enacted curriculum has been of interest to researchers who study teaching because it acknowledges the active role of teachers in designing curriculum (Connelly & Clandinin, 1986; Cornbleth, 1988; Posner, 1988; Snyder, Bolin, & Zumwalt, 1992). Studying the relationship between written curriculum materials and the enacted curriculum necessarily involves understanding teachers' processes of constructing the enacted curriculum, including the role that resources, such as curriculum materials, play in the process.

This view of curriculum assumes that the teacher is an active designer of curriculum rather than merely a transmitter or implementer. I use the term "enacted curriculum" to refer to this view of curriculum.

The Significance of Mathematics

In this review, I focus on the field of mathematics education. Although there is much to be learned by looking at curriculum use within and across different content areas, mathematics has several unique features that make it particularly significant in a study of curriculum use.

First, mathematics is a subject that has long been associated with textbooks and curriculum materials. Other school subjects, such as literacy-based subjects, have enjoyed brief periods where teachers were encouraged to draw on literature or trade books to shape their curriculum, but mathematics has a long history of being driven by the textbook. The reasons for this trend include, among others, societal views of the nature of the content and how it is learned, and the level of comfort that many teachers have with the subject. Sosniak and Stodolsky (2000) found that the same elementary teachers who tended to enrich the textbook's suggestions in reading and language arts tended to stick rigidly to the exercises offered in mathematics texts. Consequently, efforts to initiate change in mathematics teaching rely heavily on revised textbooks or curriculum materials (Ball & Cohen, 1996). The most recent example of such efforts for curriculum reform is the newest wave of *Standards*-based curriculum materials developed with funding from the National Science Foundation. The availability and increasing use of these materials provide another reason for studying teachers' curriculum use within mathematics.

Second, current reform efforts in mathematics education (NCTM, 1989, 2000) make mathematics an important context for improving knowledge of curriculum use. Because these reforms seek to accomplish substantial change in mathematics curriculum and pedagogy, and because textbooks and curriculum materials have figured significantly in mathematics teaching and in reform efforts, the field of mathematics offers a fruitful opportunity to examine teacher–curriculum relationships.

Methods of Selection and Analysis

Work on this review began with the gathering and reading of empirical research on teachers' uses of mathematics textbooks and curriculum materials, including mainstream texts, innovative curricula, and *Standards*-based curricula that totaled over 70 studies and covered 25 years. I targeted only studies that attended to how teachers interacted with, used, and were influenced by prepared curriculum resources at the classroom level, excluding a number of large-scale analyses of program implementation efforts that addressed policy and politics at the system level.

Peer-reviewed journals served as the primary sources of studies. I surveyed the contents of major journals in the fields of mathematics education, general education, and research on teaching, including *Journal for Research in Mathematics Education, Journal of Mathematics Teacher Education, American Educational Research Journal, Harvard Educational Review, Teachers College Record, Teaching and Teacher Education,* and *Elementary School Journal.* However, much of the recent research on *Standards*-based curriculum materials has yet to be published in peer-reviewed journals. Therefore, I also used ERIC to locate related dissertations and conference presentations in order to include research on teachers'

use of newly published materials. In addition, I read a number of conceptual pieces and commentaries on mathematics curriculum materials and teachers' use of them found in book chapters and journals such as *Phi Delta Kappan.* As a result of the focus on teachers in this review, I did not include studies that examined students' experiences with curriculum. Last, I read several studies of curriculum materials in academic subject areas other than mathematics—specifically, science, reading, and English. However, with the exception of one key study (Brown, 2002), I have not included those studies in this review. I chose to include Brown's work in this review because it makes a substantial theoretical and conceptual contribution to the research on curriculum use.

Using matrices, I grouped studies by publication date and, within each decade, by the types of curriculum used by teachers in the study (mainstream, innovative, or *Standards*-based). For each study, I recorded key features of the study (e.g., focus, research question, number of teachers), methods used (e.g., data collected, analytical methods, theoretical framework), and findings. The diversity of findings across the studies led me to a comparative analysis of methods and constructs used to examine curriculum use. This analysis revealed considerable variation in the meanings assigned to the concept of curriculum use, together with limited explicit discussion of the theoretical and conceptual assumptions underlying methodological decisions. I subsequently examined each study and recorded implicit or explicit assumptions about the meaning of curriculum use, curriculum materials, the teacher's role and the nature of teaching, and the teaching–curriculum relationship. Through this process I identified four ways that curriculum use was conceptualized and examined in the research. Although the four conceptions overlapped to some extent and were not always mutually exclusive, each could be associated with a particular theoretical or epistemological perspective on human activity, material use, or meaning making.

The intent of this review is to examine the conceptual underpinnings of research on use of mathematics curriculum materials in order to frame and guide future research. Because of the conceptual nature of this article, I have elected to provide illustrative examples of empirical research when appropriate rather than supply an exhaustive review of all related literature.

Multiple Meanings of Curriculum Use

Over time, studies of teachers' use of curriculum materials have changed considerably as ideas about the nature of teaching and the materials themselves have evolved. In fact, the question of *how* teachers interact with and use curriculum materials has not always been considered relevant to understanding curriculum. Historical studies of school curricula, for instance, relied heavily on textbooks of the period to reconstruct the contents of classroom practice (Love & Pimm, 1996; Walker, 1976). This approach, which viewed curriculum as fixed and the teacher as a conduit for curriculum, rather than as a user or designer, was strikingly evident in the "teacher-proof" curriculum reform efforts of the late 1950s and 1960s. In highlighting ways that teachers adapted or resisted unfamiliar curriculum programs, researchers such as Sarason Berman and McLaughlin (1978) challenged conventional assumptions that teachers merely followed their textbooks and that texts alone represented classroom instruction.

Even within a framework that views teachers as active users of curriculum materials and shapers of the enacted curriculum, researchers have taken a vari-

ety of stances on the nature of the relationship between curriculum and teaching. That is, researchers conceptualize curriculum *use* differently, and these conceptualizations are grounded in different assumptions about curriculum, teaching, and reader–text interactions. Numerous studies, for example, assume that curricula are fixed, embodying discernible and complete images of practice. A second group of studies takes classroom practice, rather than the text, as the starting point for analysis and views curriculum guides as possible influencing forces in the construction of practice. These two perspectives are not mutually exclusive. In fact, it is plausible to hold that fidelity with a curriculum guide is possible while examining the ways that a teacher uses the guide to construct her classroom practice.

A third set of studies focuses on the teacher and examines the meanings made from the text. This perspective frames the teacher as active interpreter of curricular offerings. Researchers in this group, along with many in the previous group, do not assume that fidelity between texts and teaching is possible. In recent years, a fourth category of research has emerged that overlaps with the third. Researchers in this final group look mainly at the relationships that teachers forge with curriculum resources, the factors influencing that relationship, and the effect that the relationship has on the teacher and the enacted curriculum.

To some extent, these different conceptualizations reflect more general trends in research. Many early studies, for example, focused on fidelity, whereas many more recent studies reflect a more nuanced view of the curriculum. However, there are exceptions. Below, I discuss each perspective on curriculum use and its underlying assumptions and provide examples of corresponding research. Table 1 contains a summary of the assumptions and theoretical perspectives associated with each perspective.

It is necessary to emphasize that not all research on curriculum use fits neatly into one of the aforementioned categories; I encountered several studies that straddled the boundaries of at least two classifications. This phenomenon occurs in part because the categories are overlapping; and distinctions between them are due, in some cases, to different emphases of the research. Some studies are difficult to classify because the categories themselves are analytical tools developed for the purpose of comparing research approaches. My aim in proposing the following four perspectives is not to classify the research but to illuminate the varied and sometimes conflicting assumptions underlying research on curriculum use and to consider the implications of this variation.

Curriculum Use as Following or Subverting the Text

Many studies of curriculum material use take the text as the starting point and then consider the degree to which teachers follow or subvert it. These studies hold to a somewhat positivist stance on text and assume that close fidelity between the written and enacted curriculum might be achieved under ideal conditions. In effect, isomorphism between written curriculum materials and the enacted curriculum is possible. Therefore, in many cases, these researchers concern themselves with how curriculum writers and others might achieve greater clarity and closer guidance for the teacher. These concerns are not surprising, given the ubiquity of textbooks in classrooms and the tendency for administrators and policymakers to see them as potential vehicles for change.

TABLE 1
Key assumptions and theoretical perspectives influencing conceptions of curriculum use

Conceptions of curriculum use	Following or subverting	Drawing on	Interpreting	Participating with
Conceptions of curriculum materials	Fixed representation of enacted curriculum	One of many available resources	Representation of tasks and concepts	Artifacts or tools; products of sociocultural evolution
Conceptions of the teacher's role	Enactor of planned curriculum	Active designer of the enacted curriculum	Meaning maker; draws on beliefs and experience to make meaning	Collaborator with curriculum materials to design enacted curriculum
View of teacher–curriculum relationship	Fidelity is possible and a desirable goal	Teacher has agency over curriculum	Fidelity is not possible	Participatory relationship influenced by both teacher and curriculum
Theoretical or epistemological influences	Positivism	Positivism or interpretivism	Interpretivism; reader-response literary theory	Sociocultural analysis
Focus of research: Illustrative research questions	Agency of the text as influencing factor: To what extent and under what circumstances do teachers use the curriculum with fidelity? How can fidelity be increased?	Agency of teachers: What influences the choices that teachers make? How are their choices played out in classrooms?	Nature of interpretations and resulting classroom practices: How do teachers interpret their curriculum resources? How do these inter-pretations play out in mathematics teaching?	The participatory relationship: How do teachers engage with and use curriculum resources? What teacher and curricular factors influence this relationship?

This stance is illustrated in both the findings and the recommendations contained in these studies. Stephens (1983) analyzed teachers' use of innovative curriculum materials grounded in nontraditional conceptions of mathematics, focusing on how teachers presented the nature of mathematical knowledge. Stephens found that teachers transformed the intended curriculum, imposing a rigid and narrow portrait of mathematics. Most teachers' instructional patterns focused on group management rather than mathematics. He ascribed the incongruence between the epistemological assumptions underlying program goals and how teachers tended to carry them out to the authors' failure to be aware of, or to challenge, the traditions inherent in schools. Similarly, Donovan described teachers subverting the authority of exploration-based materials by relegating exploratory activities to an aide and then giving the aims of those materials no emphasis in assessment.

Komoski (1977) found significant mismatches between the contents of teachers' guides and classroom practice, and looked to school officials, rather than text authors, to guide teachers in their use of texts. He claimed that what is "ultimately practiced in the classroom will end up quite different from the curriculum described by the curriculum office" (p. 46) unless schools are committed to helping teachers to use newly selected textbooks. In other words, following the text and making the curriculum that is experienced in the classroom as close as possible to the written curriculum can be achieved through careful attention and guidance.

Freeman and Porter (1989) also found few cases where teachers relied solely on their mathematics textbooks. Of four case studies, only one teacher was "textbook dependent." The other teachers focused on basic skills or school district objectives and used the textbook selectively to meet their goals. The authors claimed that the conviction that textbooks determine the curriculum was grounded in "a narrow view of teacher decision making" (p. 404). In addition, they suggested that greater fidelity might be accomplished through less ambiguity about issues such as the amount of time allotted to each topic and how students ought to be grouped for instruction. The authors also suggested that for textbooks to have greater influence on classroom content, teachers needed to be given stronger incentives or sanctions for following or ignoring their texts, as well as specific guidance regarding how the texts were to be used.

Several studies of teachers using *Standards*-based curriculum materials also take the curriculum as a given and examine the extent to which teachers "follow" or "implement" it. Manouchehri and Goodman (1998), for example, studied 66 teachers in 12 school districts over a period of 2 years and found substantial differences in how teachers used the programs. They attributed the differences to teachers' mathematics knowledge, their understanding of the pedagogy called for in the curricula, their experiences, and their teaching environments. They also cited shortcomings in the guidance for teachers provided by the curricula, saying that the curricula "did not provide the teachers with detailed methods of how to address the content development" (p. 36). Like other studies that view use as following or subverting, these findings suggest that, with improvements in the materials or context, greater fidelity to the written curriculum is achievable.

Curriculum Use as Drawing on the Text

By looking at the classroom before the text, some researchers have described curriculum use as ways in which teachers draw upon and incorporate texts into their instruction. These researchers place emphasis on the agency of the teacher

and view texts as one of the many resources that teachers use in constructing the enacted curriculum. The basis of this view is that "curriculum is something experienced in situations" (Connelly & Clandinin, 1986, p. 6) and that curriculum materials are resources that teachers use in the process of enacting these experiences. From this perspective, curriculum materials are helpful tools for teachers; but unlike cultural tools or artifacts (Cole, 1996; Wertsch, 1998), they do not have the power to shape human activity. Some researchers who take this perspective accept fidelity as a possibility, while others do not. In either case, they seek to understand what influences the choices that teachers make and how these choices are played out in the classroom. From this perspective, curriculum materials represent one of a large number of possible influences on teaching that these researchers study.

Researchers involved in the Content Determinants Study (Floden, Porter, Schmidt, Freeman, & Schwille, 1981; Freeman & Porter, 1989; Kuhs & Freeman, 1979) took this perspective in their efforts to uncover the range of factors that ultimately determine mathematics content in elementary classrooms. In addition to examining the influence of textbooks in determining the content covered, these researchers looked at testing, parents, district policy, and teachers' personal interests, commitments, and expertise.

Likewise, McCutcheon's (1981) ethnographic study of teacher planning looked at, among other factors, how textbooks influenced planning decisions. By following topics found in texts, teachers allowed a number of pedagogical and logistical concerns to shape how they would teach. These concerns varied from classroom control and available materials to students' prior experiences. Knowledge, attitudes, and perceptions of the context also weighed heavily in these teachers' reasoning. McCutcheon claimed that teachers tended to transform program recommendations into lessons that they could engineer in the classroom.

Although the initial focus of Sosniak and Stodolsky's (1993) research was on how elementary teachers used textbooks in four subject, their findings also fit with a view of teaching as drawing on curriculum. They observed inconsistent patterns of textbook use across teachers and school subjects and subsequently argued that rather than thinking of their textbooks as "blueprints" or "driving forces," teachers actually viewed them as "props in the service of managing larger agendas" (p. 271). These findings suggest a need for understanding teachers' larger curricular agendas and the function of curriculum materials within them.

Smith's (2000) year-long study of a middle school teacher using a reform-oriented mathematics program while participating in professional development activities also provides an example of research undertaken from a "drawing on" perspective. Smith observed this teacher's experiences as she navigated through a new curriculum, unfamiliar professional learning opportunities, and her own strong commitment to ensuring student success. By concentrating on how the teachers managed the dilemmas faced during the year and the ways that a range of opportunities and resources contributed to their teaching and learning, Smith found that the reform-based curriculum was a source of both new and potentially conflicting ideas about learning.

Curriculum Use as Interpretation of Text

A third stance that researchers have taken when studying teaching and curriculum materials is to frame the teacher as interpreter of the written curriculum. This

outlook holds to an interpretive view of text and assumes that fidelity between classroom action and written words in a teacher's guide is impossible, that teachers bring their own beliefs and experiences to their encounters with curriculum to create their own meanings, and that by using curriculum materials teachers interpret the intentions of the authors. This position has its roots in reader-response literary theory, which embraces the "phenomenological assumption that it is impossible to separate perceiver from perceived, subject from object" (Mailloux, 1982, p. 20).

In her book on teachers' encounters with curriculum materials, Ben-Peretz (1990) argues that teachers draw on personal knowledge and experience to "assign meaning to the curriculum materials they use daily in their classrooms" (p. 71). She explores the frames that teachers use to interpret and analyze curriculum materials and suggests that when teachers use curriculum materials in flexible and defensible ways, they are able to unlock much of the "curriculum potential" embedded in the materials. Research from this point of view investigates the nature of teachers' interpretations, the factors that influence them, and the resulting classroom practices.

Researchers who view curriculum use as a process of interpretation tend to apply this view to a range of media and initiatives intended to influence teaching, including education policy. In studies of the relationships among state-level policy, district practices, and classroom practices, researchers with the Educational Policy and Practice Study (EPPS)[3] maintained that policy and its multiple instantiations, such as textbooks and tests, are open to interpretation. Beginning in 1988, EPPS used case-study methods to consider how elementary teachers in California learned about, understood, and acted on state-level mathematics policy in the late 1980s. The state's initial efforts to communicate its message of reform by altering mathematics instruction placed heavy emphasis on approved textbooks. Hence, how teachers interpreted and used their new textbooks was central to this work (e.g., Ball, 1990; Cohen, 1990; Heaton, 1992; Putnam, 1992; Weimers-Jennings, 1990; S. M. Wilson, 1990, 2003).

A particularly striking finding from this research with respect to the interpretation of policy and curriculum materials was the conviction with which all of the participating teachers believed that their teaching reflected the ideas of the reform as a result of their faithful use of a particular textbook or curriculum program. However, their interpretations of the goals of the particular reform initiative and their uses of their texts varied tremendously. Variations included subtle and not-so-subtle adaptations of the plans suggested in the text, as well as diverging interpretations of what it means to engage students in problem solving or to discuss their solution strategies.

Stake and Easley (1978) also took an interpretive stance in their case studies of the state of math and science education in the 1970s. In their observations, Stake and Easley did not find one instance of mathematics or science being taught through inquiry, which was the curriculum developers' intent. Instead, the case studies depicted teachers making adaptations to the written teacher's guides that fit traditional notions about the tasks of teaching and the nature of the subject matter. The teachers who were studied seemed intent on "covering the text," by marching the students rapidly through the "inquiry" process and presenting the subject matter as facts that experts found to be true.

This stance has been influential in a number of researchers' investigations of *Standards*-based curricula. Collopy (2003) studied two teachers using the same curriculum for the elementary grades and found significant differences in their uses. The most extreme case of this kind of variation was in how the teachers used the illustrative dialogues provided in the curriculum. These scripted conversations, presented like the dialogue in a play, illustrated possible discussions that a class might have about a focal concept or phenomenon. Interestingly, one teacher read them before the class to anticipate ideas that might come up during a class discussion; in contrast, the other teacher used them as scripts and had students read the various parts aloud. Collopy attributed these dissimilar interpretations to the teachers' contrasting views of curriculum and the degree to which they had firmly established pedagogical repertoires and curriculum structures.

Chavez (2003) also focused on teachers' interpretations of curricula in his study of teachers using several different middle school curricula. His study included a survey of 53 teachers and case study analyses of three teachers, two who were using a *Standards*-based curriculum and one who was using a commercially published, traditional text. He, too, found variation across practices of teachers using the same *Standards*-based curricula. He asserted, "It is possible to 'adopt' a textbook and use it frequently without really espousing the epistemological assumptions that are attached to the textbook, and thus not change teachers' practices in ways that would better match the goals of a particular curriculum" (p. 160).

Curriculum Use as Participation With the Text

Another, less common perspective taken by researchers studying teachers and curriculum materials focuses on the teacher–text relationship, or the activity of using the text. This perspective treats curriculum material use as collaboration with the materials. Central to this perspective is the assumption that teachers and curriculum materials are engaged in a dynamic interrelationship that involves participation on the parts of both the teacher and the text. As mentioned earlier, there are significant overlaps between this view and the view that focuses on use as interpretation. The core difference is the focus of the analyses. Although researchers in either category may view curriculum use as a process of interpretation through interaction with the text, the researchers in this group seek to study and explain the nature of the participatory relationship. In other words, the distinguishing characteristic of this perspective is its focus on the activity of using or participating with the curriculum resource and on the dynamic relationship between the teacher and curriculum.

Although it is not necessarily identified by the researcher, this perspective on curriculum use stems from Vygotskian notions of tool use and mediation, wherein all human activity involves mediated action or the use of tools by human agents to interact with one another and the world (Cole, 1996; Vygotsky, 1978; Wertsch, 1991, 1998). These tools, as "products of sociocultural evolution" (Wertsch, 1998), both shape and are shaped by human action through their affordances and constraints. The idea that both the curriculum and its users change through this interactive process is reminiscent of McLaughlin's (1976) earlier observations of the mutual adaptation of policy. In the Rand change agent study, McLaughlin and her colleagues found that implementation of innovation was most effective when

teachers and administrators engaged in a process of adapting the project designs to their particular circumstances. This process included adaptation of the local setting and learning on the part of the participants. Accordingly, one characteristic of much of the research that examines use as participation with the text is attention to the effect on the teacher. These studies not only look at how teachers engage with, use, shape, adapt, and interpret curriculum materials but also consider how teachers change or learn from their use of these resources (e.g., Davenport, 2000; Remillard, 2000, Van Zoest & Bohl, 2002).

The view that curriculum material use involves a dynamic interchange between teacher and curriculum, agent and tool, is reflected in Lloyd's (1999) study of two high school teachers using a *Standards*-based curriculum. The study investigated "how and why two teachers encountered particular successes and difficulties as each implemented a set of novel curriculum materials for the first time" (p. 229). The author examined the teachers' conception of the curriculum and of key ideas central to it, including exploration and cooperation, and the teachers' resulting mathematics teaching. She argued that "curriculum implementation consists of a dynamic relation between teachers and particular curricular features" (p. 244) but also suggested that this relationship can be strained by tensions between the structure outlined in the curriculum guide and the teachers' need to construct curriculum that is responsive to students.

Remillard's (1996, 1999, 2000) study of two teachers using a textbook that represented a commercial publisher's response to the NCTM *Standards* (1989) also examines teachers' participation with curriculum. The study illustrates how two fourth-grade teachers interacted with the same text in different ways to construct contrasting opportunities for student learning. The analysis highlights the ways the teachers read the textbook and explores the factors that contributed to different approaches to reading. Not only did the two teachers read entirely separate parts of the textbook (exercises for students as opposed to supplementary activities), but they also read for different purposes (potential activities and assignments as opposed to big ideas to guide planning). These contrasting uses of the textbook produced different opportunities for learning for students.

Sherin and Drake's (2004) analyses of 10 elementary school teachers using a reform-based curriculum designed by mathematics education researchers is another case of research that examines teachers' participation with curriculum. By looking closely at "the key processes involved in teachers' use of curriculum materials" (p. 4) and ways that teachers engage in these processes, Sherin and Drake sought to understand "the chain of events whereby a set of curriculum materials leads to specific instances of classroom instruction" (p. 6). The chief processes that they studied were reading, evaluating, and adapting. They considered when teachers engage in these processes and to what ends. Their finding—that each teacher tended to follow a particular pattern of use and that these patterns or curriculum strategies differed across teachers—highlights the importance of understanding teachers' approaches to curriculum use.

Brown's (2002) study of middle school teachers using an inquiry-based science project provides yet another example of research that looks at how teachers "appropriate and mobilize instructional resources" (p. 1). Taking the position that using curriculum resources is necessarily a process of design, Brown sought to characterize and explain the variety of different practices in relation to the

curriculum observed across the three teachers. He found that at different times and in different situations, teachers "offloaded" responsibility for the design process onto the curriculum and used a recommended activity as outlined by the authors, "adapted" curriculum recommendations from their original offerings, and "improvised" by relying fully on their own design initiatives and minimally on the curriculum. In an effort to explain the variation that he observed in curriculum use within and across teachers, Brown examined the individual resources that teachers brought to their exchanges with the curriculum, as well as cognitive and physical affordances of the curriculum. In his Design Capacity for Enactment framework, Brown identified teachers' curricular practices as resulting from the dynamic relationship between the features of the curriculum resources and the teacher resources.

Implications for Studies of Curriculum Use

As noted earlier, my aim in highlighting the range of ways that researchers conceptualize and study curriculum use is to consider implications for how this research contributes to understanding in the field. In one sense, the variation in perspective and focus permits scholars to reveal distinct dimensions or angles of a complex phenomenon. That is, we gain different (though equally important) insights about teaching and curriculum materials depending on whether we regard teaching as the primary unit of analysis or focus on teachers' interactions with a particular curricular resource.

On the other hand, as the previous analysis indicates, much of the research rests on varied theoretical assumptions—about curriculum and its representation, teaching and its embodiment, the nature of reading and interpretation of text, and human activity itself—that are not identified explicitly by the researcher. It is my contention, then, that the contribution of the research can be assessed only after these fundamental assumptions are revealed and questioned. Thus the field of research on teachers' use of curriculum materials has the opportunity—and arguably the necessity—to take up critical theoretical issues that are at the very heart of the questions that have driven the work thus far. Unless this opportunity is acted on, progress will be limited.

In the following two sections, I draw on both empirical and conceptual analyses of teaching and curriculum materials to propose conceptualizations of each that hold up to studies of curriculum use. My purpose is not to provide an extensive review of the literature but to clarify these constructs sufficiently to develop a framework for future research. As the following discussion reveals, more literature exists on the nature of teaching than on curriculum. Although the work of teaching has been the subject of a great deal of research and theory, curriculum guides or resources have received minimal attention.

Conceptions of Teaching with Respect to Curriculum

Research findings on teachers using curriculum and on teaching in general highlight several characteristics of the work of teaching that have relevance to the framework on teachers' curriculum use. These include the active nature of teachers' work as curriculum designers, the multidimensional nature of curriculum design, and the significance of individual teachers' characteristics and resources in this process.

Teaching as Curriculum Design

The distinction that most scholars of teaching and curriculum draw between the written and enacted curriculum suggests that teachers are not mere conduits or implementers of curriculum but active agents who, through their work with students, construct the enacted curriculum (Clandinin & Connelly, 1992). Ben-Peretz (1990) used the term "curriculum development" to signal the way that this work was comparable to that of curriculum writers. She argued that there are really two phases of curriculum development. The first phase is what curriculum writers do when they conceptualize curricular plans and write them in resources for teachers. The second phase is what teachers do as they alter, adapt, or translate textbook offerings to make them appropriate for their students. In discussing the teacher's role in curriculum development, Ben-Peretz referred to the deliberate actions of teachers engaged in "uncovering the potential of curriculum materials so that these can be reconstructed for particular students and for specific classroom situations" (xiv).

Some scholars of teaching take this notion further, arguing that the curriculum development or design work done by teachers goes far beyond selecting and redesigning curriculum plans; it involves enacting those plans in the classroom with students. In a study of the relationship between mathematics instruction and students' thinking, Stein, Grover, and Henningsen (1996) observed distinctions between the tasks that teachers initially presented to students and how they were implemented by the teacher and students during the course of a lesson. These researchers found that by adjusting particular features of reform-oriented tasks while students worked on them, teachers decreased their cognitive demands, illustrating the responsive, interactive, and emergent nature of the enacted curriculum. Even teachers who followed textbook suggestions as closely as possible made curriculum-development decisions when enacting their plans with students in the classroom. Because teachers must respond to the unscripted actions of students in an unscripted context, enacting curriculum necessarily involves making in-flight decisions. Some have referred to this activity as the improvisational work of teaching (Borko & Livingston, 1989; Heaton, 2000; Remillard, 1999; Yinger, 1987, 1988).

The view of teachers as curriculum developers overlaps with recent work on teaching and pedagogy as design (Brown, 2002; Brown & Edelson, 2001; New London Group, 1996). Like developing or producing curriculum, the term "design" captures the creative and in-process characteristics of teaching. "The notion of design connects powerfully to the sort of creative intelligence the best practitioners need in order to be able, continually, to redesign their activities in the very act of practice" (New London Group, 1996, p. 5). The concept of design emerges from the growing field of design research and theory that conceptualizes design as "a sequence of decisions made to balance goals and constraints" (Edelson, 2002, p. 108) and design research as an iterative process of design and implementation in which each cycle of implementation affords opportunities to study both the artifact under design and the implementation process.

Although design research traditionally has focused on material artifacts, such as curriculum materials and other tools, Brown and Edelson argue that teaching itself is a design process in which "teachers actively shape the instructional environment using available resources in order to achieve their goals" (p. 9). Therefore, teachers' processes of reading, interpreting, translating, and adapting

curriculum resources as they shape and reshape instruction are practices of design. Any model of teachers' curriculum use must be able to capture and represent the design work undertaken by teachers.

Teaching as Multidimensional

The distinction between designing curriculum plans and designing curriculum as it is enacted, as illustrated by Stein et al. (1996), hints at the multidimensional nature of teaching and curriculum design. In other words, teaching is more than what teachers do in the classroom with students. Two studies of curriculum materials use by teachers of mathematics (Remillard, 1999; Sherin & Drake, 2004) illustrate the different dimensions of teaching in relation to curriculum and have produced models that have promise in framing future studies.

Remillard's Arenas of Curriculum Development.

Through a study of two fourth-grade teachers' first-time use of a commercially published textbook released after the *Standards,* Remillard (1996, 1999) identified three arenas of curriculum development activity that teachers engaged in as they used the text in their mathematics teaching. The term "curriculum development" was taken from Ben-Peretz's (1990) view of the teachers' role in interpreting and adapting written curriculum materials. Each arena defines a particular realm of the curriculum development process about which teachers explicitly or implicitly make decisions (see Figure 1).

The *design* arena involves selecting and designing tasks and activities for students. In examining the two teachers' work in this arena, Remillard (1999) focused on the their approaches to reading the text. The *construction* arena involves enacting these tasks in the classroom and responding to students' encounters with them. Remillard used the term *task adaptation,* "the unrehearsed adapting and

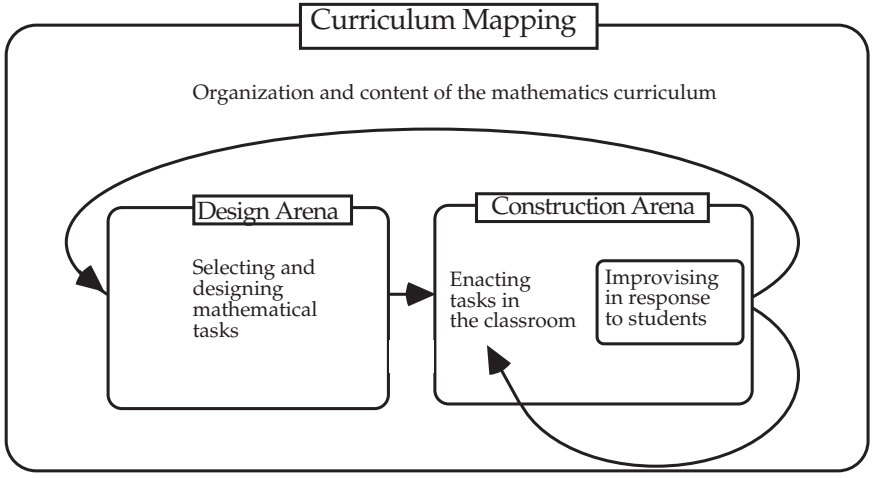

FIGURE 1. *An overview of Remillard's (1999, p. 322) three arenas of curriculum development. Copyright 1999 by Blackwell Publishing. Reprinted with permission.*

adjusting of tasks in order to facilitate students' work with them," to refer to the primary activity of the construction arena (p. 328). Regardless of how the teachers used the textbook to select tasks, enacting them required both teachers to make on-the-spot decisions about how to adapt them in response to classroom events. In this arena, Remillard found that the teacher would first "read" students and the tasks as students engaged in them, rather than the text, and then improvise adaptations.

The *mapping* arena involves making choices that determine the organization and content of the mathematics curriculum over the year. Unlike the previous two arenas, the mapping arena is not directly related to daily classroom events but affects and is affected by them. The decisions that teachers made in this arena were not always readily apparent.

> Textbooks offer a curriculum map that organizes mathematical topics into sections, each including specific concepts or skills. Teachers map the curriculum when they decide how or whether to use these structures. . . . Teachers also map the curriculum when they elect to go through each chapter in sequence, taking one lesson each day. . . , or when they abandon the text altogether and develop alternative maps. (p. 334)

In addition to illustrating the different ways that teachers might engage curriculum materials within each arena, the three arenas highlight the multiple dimensions of curriculum use. Such findings help to explain inconsistencies that appear in the literature on textbook use that resulted from researchers focusing on different arenas. Because of the limited role that the text played in the teachers' efforts to adapt tasks in the construction arena, Remillard identified this arena as an important point of focus for future research (1996, 1999) and curriculum development (2000).

Sherin and Drake's Models of Curriculum Use

Sherin and Drake's (2004) analysis of 10 elementary school teachers' initial uses of a noncommercially published curriculum, designed by mathematics education researchers, examines how teachers engage with the materials at different phases of teaching: prior to, during, and after the lesson. In each phase, the researchers examined "three key processes in which teachers engage as they use curriculum materials" (p. 5): reading, evaluating, and adapting. Sherin and Drake analyzed each teacher's approach to these processes, their chronology, and the interrelationships among these processes. They refer to the patterns for each teacher as "curriculum strategies," noting that the patterns remained stable throughout the year.

In examining the process of reading the curriculum, the researchers considered when the teachers read the materials and for what purpose. They identified three general approaches: (a) reading for big ideas prior to instruction; (b) reading for lesson details prior to instruction; and (c) reading for big ideas prior to and for details during instruction. The three teachers who relied on the third approach managed to attend to the overarching goals of the lessons as well as to their specific elements.

Sherin and Drake defined *evaluating* as teachers' attempts to judge aspects of the materials, such as the mathematics and instructional strategies included. A significant difference among the teachers' evaluation processes was whom they had in mind as the audience, the teacher, the students, or other constituents, such as parents or administrators. The finding that 7 of the 10 teachers considered themselves

	Read	*Evaluate*	*Adapt*
Before Instruction	Examines main activities in lesson. Examines new vocabulary introduced in lesson.	Considers own understanding of conceptual connections among activities in lesson.	Creates transitional activities.
During Instruction		Considers students' understanding of mathematics in lesson.	Creates new explanations and new terminology.
After Instruction		Considers whether students need more review. Considers whether she successfully managed activities in lesson.	

FIGURE 2. *An example of one teacher's curriculum strategy. From Sherin & Drake (2004), Figure 2. Reproduced with permission of the authors.*

as the audience indicates that a majority of teachers in this study attended to their own understanding and use of the materials as well as to that of the students.

Noting the impossibility of a complete match between written and enacted curriculum, the researchers focused their analysis of teachers' adaptations on "significant changes that teachers make in the intended curriculum such as changes in the structure of a lesson, in the activities that comprise the lesson, or in the purpose of the lesson" (p. 30). Most often, adapting occurred simultaneously with evaluating, in the form of creating new tasks, examples, or materials and adding them to the existing materials, replacing one part of a lesson with something else, or omitting part of a lesson.

Because they found substantial consistency in each teacher's approach to all three processes, Sherin and Drake posit that, at least in the first year of use, a teacher has a stable curriculum strategy. Figure 2 offers an example. By delineating each teacher's curriculum strategy, Sherin and Drake were able to identify patterns across teachers that have implications for further research and practice. For example, they found that teachers who evaluated with the teacher in mind before instruction and with the students in mind during instruction tended to adapt by creating new components to the curriculum. The researchers assess this tendency as "a proactive sense of collaborating with the curriculum" (p. 24), and even go so far as to suggest that teachers attending to their own understanding prior to instruction provided a foundation from which to evaluate and adapt with students in mind. As a result, they were less inclined to omit portions; rather they tended to create additional components that they believed would foster students' understanding.

An important contribution of Sherin and Drake's framework is that it highlights and examines details of teachers' interactions with the particular curriculum. Their findings reveal that using a novel curriculum is a complex and multifaceted process of interaction with materials. Moreover, this study reinforces Remillard's (1999) claim that teachers approach these interactions in substantially different ways.

Individual Teacher Characteristics and Resources

Many studies of teaching and teachers' uses of curriculum materials highlight teachers' varied approaches to designing curriculum and seek to explain these differences in terms of individual teacher characteristics.[4] The idea that teachers' beliefs about (Thompson, 1992) and knowledge of (Fennema & Franke, 1992)

mathematics, teaching, and learning influence their teaching decisions is well established in the literature. Furthermore, these cognitive characteristics have been found to have considerable influence on teachers' responses to calls for curricular reform, because the content of the reforms often conflicts with widely held beliefs about mathematics, teaching, and learning (Franke, Carpenter, & Fennema, 1998; J. P. Smith, 1996). Some researchers have sought to clarify the role that such individual characteristics play in curriculum use. The following discussion identifies individual characteristics that have figured prominently in these studies.

Brown (2002) examined three middle school teachers' interactions with an inquiry-based science unit that was designed by education researchers in collaboration with public school teachers. His analysis targeted the ways that teachers used the particulars of the curriculum to design instruction. Doing so, he argued, is a complex activity in which teachers "perceive and interpret existing resources, evaluate the constraints of the classroom setting, balance tradeoffs, and devise strategies—all in the pursuit of instructional goals" (p. 27). In his discussion of the teacher resources involved in teacher–curriculum interactions, Brown, like a number of scholars, identified pedagogical content knowledge (Shulman, 1986), subject matter knowledge, beliefs, and goals as influential factors in teaching and teachers' use of curriculum (e.g., Remillard, 1992; Romberg, 1997; Stephens, 1982; Thompson, 1984; M. Wilson & Goldenberg, 1998).

Brown (2002) also proposed the construct of *pedagogical design capacity* as a way to characterize an individual teacher's ability "to perceive and mobilize existing resources in order to craft instructional contexts" (p. 70). A fundamental term in this definition is "mobilize." Instructional capacity, Brown asserts, is not merely a function of teacher knowledge—it is the ability to act with and on that knowledge.

Various researchers have identified additional factors that contribute to teachers' interactions with and uses of curriculum. One such factor that appears to be significant is a teacher's beliefs about or stance toward curriculum materials. Evidence indicates that teachers view curriculum materials and textbooks as authoritative (Remillard, 1991; Romberg, 1997; Stake & Easley, 1978), inflexible (Chavez, 2003), or as artifacts of tradition (Ball & Feiman-Nemser, 1988). Remillard and Bryans (2004) found that teachers' stances on what curriculum materials are and what they represent as resources for teachers influenced the way they used *Standards*-based materials more than the extent to which the materials matched the teacher's beliefs about mathematics.

Some scholars have indicated that a teacher's professional identity is another characteristic that contributes to curriculum use. Smith (1996) identified self-efficacy as highly influential in teachers' pedagogical decisions and suggested that many of the practices called for by the NCTM *Standards* (1989, 2000) run counter to traditional views of effective teaching. In this sense, teaching is deeply connected to the formation of one's identity, and changing one's teaching involves identity reformation (Spillane, 2000). Researchers have found that teachers' interactions with novel curriculum materials are influenced by their own sense of themselves as teachers (Drake & Sherin, in press), as users of curriculum (Lloyd, 1999; Romberg, 1997), and as authorities in the classroom (Frykholm & Pittman, 2002; M. Wilson & Lloyd, 2000).

In his study of middle school teachers using *Standards*-based mathematics curricula, Frykholm (2004) took account of several individual teacher characteristics

all associated with discomfort that teachers experience when using unfamiliar curricula. He identified four domains of discomfort commonly experienced by teachers using *Standards*-based curriculum materials: cognitive, belief-driven, pedagogical, and emotional. Frykholm argued that use of these materials is necessarily influenced by one's tolerance for discomfort in each domain.

Some studies have also indicated that teachers' perceptions of the needs and capacities of their students affect their use of curriculum. As Sherin and Drake (2004) point out, teachers often read new curriculum materials with the students as the audience and make determinations about how to use and adapt suggested activities with students' needs in mind. In some cases, teachers' perceptions of students' deficits figure significantly in their negative responses to *Standards*-based curricula (Collopy, 2003; M. Wilson & Lloyd, 2000).

When considered together, studies on the characteristics and resources that influence curriculum use highlight several themes. First, teachers matter in the curriculum-use equation. The individual resources and perspectives of teachers help to explain, in part, the differences seen across teachers in curriculum use, especially when they are working with the same curriculum. Second, patterns that exist across studies reveal the types of characteristics that are particularly prominent as influencing factors. Third, although knowledge and beliefs are the most studied of individual characteristics, a number of additional factors have appeared in the literature particular to teachers' curriculum use. These factors, including teachers' orientation toward curriculum and professional identity, have the potential to expand understanding in the field of the teachers' curriculum use.

Conceptions of Curriculum Materials

Much has been written about the work of teaching, but relatively few efforts have been devoted to examining and conceptualizing curriculum materials. During the period of curriculum reform that followed the launch of Sputnik, many developers assumed that curriculum materials could direct teaching and structure students' experiences (Dow, 1991). Efforts to regulate teaching through mechanisms such as curriculum, referred to by Cohen (2000) as the "remote control" approach to reform, are seen by researchers as largely unsuccessful.[5] Nevertheless, the failure of this approach seems to have prompted few analyses of what curriculum materials represent in relation to teaching. The analyses that are available offer insights into the relationships between the materials themselves, the ideas they represent (which are at once mathematical and pedagogical), and the teaching they are designed to support.

In his exploration of the concept of text and textbook, Otte (1986) argued that one must consider the text as both an "objectively given structure of information" (the physical form that the text takes), and a "subjective scheme" (how it is understood or perceived). Subjective schemes encompass tradition and culture and mediate the reader's interpretation of the objective structure. In the discussion that follows, I examine mathematics texts first as subjective schemes and then in terms of their objective structures.

Texts as Subjective Schemes

Scholars generally agree that curriculum guides are distinct from teaching itself and cannot prescribe the enacted curriculum. This is the case on both the practical

and conceptual levels. From a practical perspective, it is simply impossible for curriculum developers to address all the needs of individual schools and classrooms. As a curriculum developer, Susan Jo Russell (1997) asserts:

> No matter how well curriculum materials are tested and how many times they are revised, each school brings its own resources and barriers; each classroom brings its own needs, styles, experience, and interests. . . . And each day in the classroom brings its own set of issues, catastrophes, and opportunities. . . . At some point, we have to decide that the curriculum materials themselves are good enough—ready for teachers to use and revise in their own classrooms. (p. 251)

Otte (1986) addressed this distinction on a conceptual level, noting that the textbook is "produced by a human being for the purpose of communication" (p. 175). The function of the textbook is to communicate a particular pedagogical representation of selected content. Using texts, he explains, involves a "transformation of space into time," from the ideas represented in the text to the real time of the classroom. Otte explains that with this transformation, isomorphism between the text and the lesson is impossible:

> Something additional happens upon reading and interpreting texts, especially texts in mathematical textbooks. Reading is not automatized like breathing, walking, or seeing. Hence the problem of the interaction between text as a subjective scheme and text as an objectively given structure of information stands as a permanent problem not to be solved once and for all. This, however, requires that the textbook is not conceived of as a written lesson protocol. (p. 175)

Brown (2002) used the analogy of the relationship between sheet music and music performed to illustrate what he describes as "the complex relationship between tools and the practices they facilitate" (p. 14). As an example, Brown compared Duke Ellington's rendition of "Take the A Train" to one by Ella Fitzgerald and made the following observations:

> First, we have little difficulty identifying each rendition as being the same song.
>
> Second, we find that despite their essential similarities the songs sound distinctly different (note that the same can often be said for two renditions by the same artist). Third, we can examine, as music critics often do, the sources of this variation—ranging from obvious differences such as instruments used to less obvious ones such as cultural influences, contextual factors, and stylistic preferences. Finally, few would argue that although performers use pre-rendered scores as foundations to support their practice, indeed a bulk of the creative work is taking place during the performance. (pp. 14–15)

Rather than focusing on the relationship between the text and teaching, Kang and Kilpatrick (1992) explored what the mathematics text represents in relation to mathematical knowledge. Drawing on didactic transposition theory (Chevallard, 1988), they distinguish between knowledge as it is known and used and knowledge as it is packaged or structured for the purposes of teaching others. Structuring knowledge to be taught to others requires a didactic transposition that necessarily involves altering it. For example, knowledge that is indeed dynamic and "unsteady," like the

messy work of proving a theorem, is often portrayed as static and tidy when presented as a proof in a book. Another example of didactic transpositions is the way that knowledge is broken down and given a form considered amenable to learning.

The two previous examples of didactic transpositions illustrate the ways that these transpositions have epistemological and social entailments as a result of their sanctioning particular types and forms of knowledge. Consequently, the textbooks and curriculum materials that result from such transpositions reflect social and ideological views of knowledge and how it is learned. Similarly, Stray (1994) suggests that the messages appearing in texts are "multiply-coded," because "the coded meanings of a field of knowledge (what is to be taught) are combined with those of pedagogy (how anything is to be taught and learned)" (p. 1).

Another aspect of the subjective schemes of textbooks that offers a lens for analysis is for whom they are written. Love and Pimm (1996) claim that mathematics textbooks are primarily for students. Not only are they written for the purpose of teaching, but they also contain exercises exclusively for students to perform; some consist only of such exercises. This image applies to most commercially marketed textbooks published prior to the release of the 1989 NCTM *Curriculum Standards,* but is less applicable today. The *Standards,* along with other reform documents, called for significant change in *how* mathematics was taught as well as *what* was taught. As a result, curriculum materials became seen as a resource for teachers as much as they were a source of activities for students. Many of the curriculum writers who were funded to develop *Standards*-based curricula sought to develop materials that helped teachers to imagine different ways of structuring mathematics classrooms and interacting with students. Subsequently, a number of studies of curriculum use began to examine the extent to which curriculum materials could be designed to be educative for teachers (e.g., Collopy, 2003; Davenport, 2000; Lloyd & Wilson, 1998; Remillard, 2000).

Brown (2002) offered a conception of curriculum that has considerable promise in studies of teachers' interactions with materials. Drawing on sociocultural theory (e.g., Cole & Engestrom, 1993; Pea, 1993; Vygotsky, 1978; Wartofsky, 1973), he characterizes curriculum resources as "artifacts," or tools that are part of the material world made and used by humans to accomplish goal-directed activity. Curriculum resources have material dimensions, but as constructions of culture they also have social and cultural meaning. As cultural artifacts that mediate human activity, curriculum resources have the potential to enable, extend, or constrain human activity. From this perspective, the use of curriculum resources can be viewed as the use of a cultural tool.

Texts as Objectively Given Structures

All studies on teacher–curriculum interactions explicitly or implicitly frame what Otte (1986) labeled "objectively given structures," described by Love and Pimm (1996) as "what can be seen when looking at such materials" (p. 379). However, a perusal of various studies on curriculum use reveals substantial variation in what counts as the text. For example, Bush (1986) studied preservice secondary teachers' decision making and claimed a strong dependence on textbooks. A careful analysis of the transcriptions provided, however, reveals that following the text actually referred to determining and sequencing mathematical topics, not teaching them. He quoted one typical response from a student teacher,

who tended to "pick out the topics they [the text] want to talk about, then I explain it freehand on the board" (p. 25).

Other researchers count topics and skills taught and time allocated to them as part of the text. In their study of textbook use, Freeman and Porter (1989), for example, considered the use of exercises on the student pages but not other aspects of the text. In contrast, Sosniak and Stodolsky (1993; Stodolsky, 1989) also accounted for teachers' use of the pedagogical suggestions provided in the teacher's guide and for the extended activities for students not included on students' pages. Finally, some researchers, most often those studying the use of innovative and *Standards*-based curriculum materials, view the text as representing a particular stance or philosophy and examine the degree of match between the epistemological or theoretical assumptions underlying curriculum and teachers' practices (e.g., Chavez, 2003; Donovan, 1983; Preston & Lambdin, 1995; Stephens, 1982). These researchers differentiate between going through the motions of following a curriculum and truly embracing its message and intent.

Such variations in how the curriculum is framed across studies have obvious implications for research methods and potential learning about the teacher–text relationship. They signal a need for more work on framing and conceptualizing the components of curriculum materials. The following examples represent initial forays into this unexplored terrain.

One way to characterize the components of a curriculum is by what it offers its users. The offerings that receive the most attention by curriculum selection committees are usually the representation and structure of mathematics and the activities for students. I identified these as the *structure* of the curriculum (Remillard, 2002). Most frequently, structures are organized into daily lessons that include student exercises and activities as well as auxiliary activities. Implicit in these offerings are the authors' views of mathematics and how it is learned, but they are communicated *through* the teacher by directing her actions.

Curricula that seek to influence teaching also include suggestions for the teacher or actions the teacher is expected to perform and information for the teacher to read and use. These offer insights into the authors' assumptions about teaching and curriculum use and represent attempts to speak *to* the teacher. Traditionally, curriculum materials have focused on speaking *through* the teacher. However, curriculum writers seeking to design materials that are educative for teachers have begun to explore ways to speak *to* teachers about such matters as mathematical ideas, pedagogical strategies, and student responses (Remillard, 2000).

In his analysis of science curriculum, Brown (2002) offered a slightly different way to categorize the components of curricular artifacts. He identified three classes of artifacts within the curriculum: (a) physical objects and representations of objects, (b) representations of tasks, and (c) representations of concepts. He used the term "physical objects" to denote "the material nature of the curriculum materials themselves" (p. 52), which includes accompanying tools and materials. The reference to representations of objects indicates that not all objects suggested for use in the curriculum come with it; some are recommended only. Similarly, Brown used the term "representations of tasks" because the curriculum provides "instructions, procedures, and scripts" (p. 54) that represent the tasks. The materials do not include the actual tasks, because those can only be enacted by people. He noted that some of the representations of tasks contained in curriculum resources are for

students to enact, such as problems to solve or experiments to perform, and that others are for the teacher to enact, such as recommendations for how to structure a lesson or introduce a concept. Finally, representations of concepts refer to the depictions and organization of the content domain and the relationships within it through a variety of means, including diagrams, models, analogies, descriptions, and explanations.

Regardless of how the material features are classified, underlying and closely related to them are less-noticed elements of curriculum materials. Love and Pimm (1996) highlight the *presence* of the text as one example. As a presence, they explain, "the text is complete, already finished" (p. 379), a problem with didactical transpositions. In this sense, it represents the past within a present (the classroom) that is in the midst of unfolding. Although possibly unavoidable, the completeness brings with it a sense of authority.

Another element of the presence of a text is its *voice,* a feature of curriculum materials discussed by Herbel-Eisenmann, (2000), Love and Pimm (1996), and Remillard (2002). Voice refers to how the authors or designers are represented and how they communicate with the teacher and the students. In most curriculum materials, the authors are invisible, and little information is provided about their identity or experiences. Herbel-Eisenmann used discourse analysis tools drawn from Morgan (1996) to analyze the voice of a unit from a *Standards*-based middle school curriculum, focusing on how the authoritative structures in the writing constructed the author, the reader, and mathematical reasoning. For example, she noted the absence of first-person pronouns and suggested that it concealed the presence of human beings in the design of the text. In addition, the authors' frequent use of second-person pronouns in conjunction with objects in statements such as "the graph shows you" obscures the authority of the authors and gives inanimate objects power to perform animate activities.

Herbel-Eisenmann also noted that the most common use of the second-person pronoun was "you + verb," as in "you find." By using this construction, she argued, the authors are telling the readers about themselves, "defining what they [the authors] think the reader is doing." And in doing so, the authors are "controlling the common knowledge" or "defining and drawing attention to it" (p. 57). Herbel-Eisenmann acknowledges that some of these discourse patterns may be unavoidable, given that authors are forced to assume or establish common knowledge among readers. Other patterns, as in the curriculum that she analyzed, may be the result of pressure from publishers. In any case, what is particularly important about Herbel-Eisenmann's analysis is that it reveals the ways that authors of *Standards*-based curricula may find themselves undermining their own efforts to foster a view of mathematical knowledge as constructed by the learner, a view that locates a sense of authority for knowing and thinking within the learner.

Curriculum materials also have a highly visual dimension, which I refer to as their *look* (Remillard, 2000). Many of the commercially designed texts, for example, have a decidedly commercial look. They are printed on glossy pages, contain color photographs of smiling children, and include pages that read like advertisements for the materials. Most noncommercially developed materials have a look that seems subtle in comparison. For whatever reason, probably cost, noncommercially developed materials tend to be printed in black and white or with limited use of color. They also make limited use of photographs and font varieties. Love

and Pimm (1996) point out that curriculum materials contain visual representations and images that have a variety of purposes, some that are related to the mathematical ideas or instructional activities and others that are superfluous. Although the mathematical representations also fit into Brown's (2002) class of representations of concepts, both mathematical and nonmathematical representations contribute to the look of the text.

It is evident from the preceding discussion that curriculum materials represent much more than static collections of tasks and lesson plans. As Otte (1986) points out, an analysis of curriculum must consider both the objectively given structures and how the structures are perceived. Focusing first on curricula as subjective schemes, we are reminded that when interacting with curricular resources, teachers do not encounter the structures alone. Instead, their encounters occur within a context that assigns to the curriculum a particular meaning. In other words, teachers' interactions with curricula may be shaped by their perceptions of the curricula (Remillard & Bryans, 2004). Curriculum developers may seek to design materials that will prompt new perceptions of curriculum materials as resources for teachers. However, if texts as subjective schemes shape how teachers read and interpret these new structures, limited change may be likely.

Focusing on the objectively given structures, we see that the resources provided in any curriculum represent a complex set of plans, activities, scripts, suggestions, information, explanation, and messages that have both textual and visual entailments and are likely to speak to different readers in different ways. We know little about how teachers engage these varied offerings. As Brown (2002) asserts, much of what is in a curriculum resource is representational, in that it provides not actual activities or concepts but representations of them. Therefore, these representations can be taken up and brought to life in the classroom in significantly different ways.

The analyses of both the objective features and the subjective schemes associated with curriculum materials provide multiple lenses through which researchers might examine and understand teachers' work with resources. Thus far, such analyses have had a minimal role in examinations of curriculum use.

The Teacher–Curriculum Relationship

In the preceding analyses of research, the teacher–curriculum relationship emerges as a significant construct in understanding teachers' curriculum use. This relationship is brought to the forefront by studies that view curriculum use as *participation with* curriculum materials and examine how teachers actively engage or collaborate with curricular resources. Many studies from varied perspectives have pointed to the active and interactive nature of teachers' work when shaping the enacted curriculum, indicating that teaching is a responsive and improvisational activity that cannot be scripted. However, studies that have focused on how teachers participate with curriculum materials have found that their reading of it is actually a highly interactive and multifaceted activity, rather than a straightforward process as may be assumed.

The models of teachers' curriculum use offered by Brown (2002), Remillard (1999), and Sherin and Drake (2004), for example, illustrate the various ways that teachers draw on their own resources and capacities to read, make meaning of, evaluate, adopt, adapt, and replace the offerings of the curriculum. Teachers make

explicit or tacit decisions about what to read, and they read for different kinds of information.

Clearly, teachers' work as they interact with curricular resources is critical to understanding curriculum use and merits further examination. Brown (2002), for example, argues that understanding how a teacher uses curriculum resources and the resulting classroom practices requires an integrated analysis of the teacher's resources, the particular curriculum resources, and how they interact. This stance suggests that features of the curriculum matter to curriculum use as much as characteristics of the teacher. While it is common for studies of teachers' curriculum use to delve deeply into individual teachers' resources and characteristics, it is less common for researchers to examine use through analyses of the structures and features of the curriculum. *Standards*-based mathematics curriculum materials, for example, tend to be treated as similar for understandable reasons. However, comparisons of teachers' participation with them could reveal significant differences among these resources and shed light on how teachers interact with particular features and characteristics. As a result, the teacher–curriculum relationship and specific characteristics of the curriculum, along with teacher characteristics, are prominent features in the framework introduced in the next section.

Framing Future Research

To discuss directions for future research that grow out the preceding examination of the literature, I offer a framework that highlights relevant dimensions of and interactions within the teacher–curriculum relationship (Figure 3). This framework

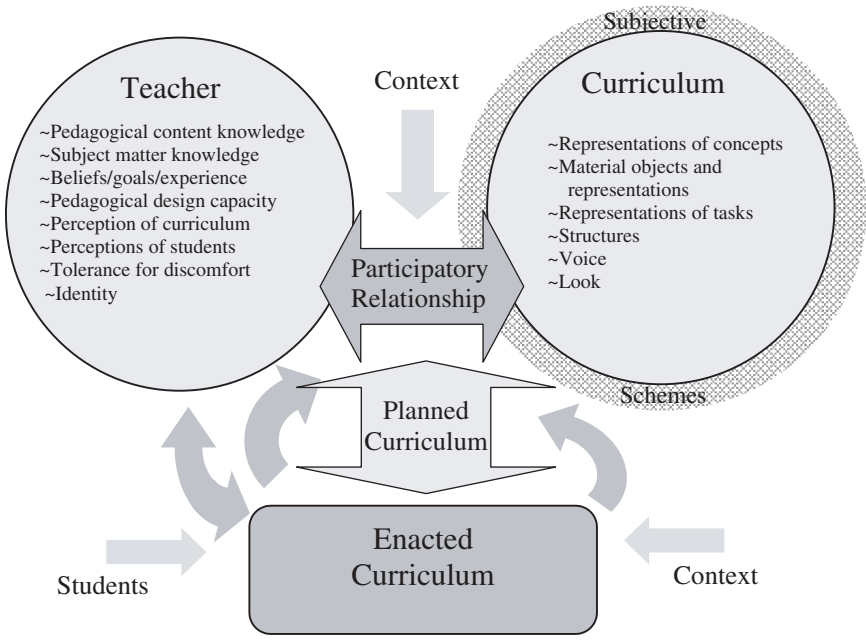

FIGURE 3. *Framework of components of teacher–curriculum relationship.*

includes key constructs that have emerged through the previous synthesis of empirical research and represents an attempt to uncover their theoretical roots. It assumes a perspective that curriculum use involves a participatory relationship between the teacher and the curriculum, and it highlights this relationship as a needed focus of further research. The framework also accommodates two other stances discussed previously: use as interpretation of text and use as drawing on the text. The positions that curriculum use involves participation with the text and that it involves interpretation of the text overlap with each other a great deal. The primary difference is focus. Much of the research that frames use as drawing on the text also embraces an interpretive perspective and focuses on a wider range of teaching activities and use of resources.

The framework, on the other hand, does not easily accommodate a stance on curriculum use that focuses on fidelity. The preceding analyses of teaching, curriculum materials, and materials use suggest that fidelity as a descriptor of curriculum use may be a misleading construct. While examining how teachers understand and use particular features of curriculum materials is certainly valuable, the evidence suggests that a written curriculum cannot fully capture or represent teaching. As discussed above, teachers play a fundamental role in reading and interpreting the offerings in curricular resources. That said, studies that treat the degree of fidelity or closeness to the intended curriculum as a dependent or independent variable continue to have a place in this body of research. Indeed, a report published by the National Research Council (2004) evaluating the research on curriculum effectiveness recommends that studies of the impact of curriculum on achievement include analyses of the degree of implementation as an independent variable. However, degree of implementation or fidelity must be carefully and clearly delineated. As the previous analyses of curriculum materials as complex and multifaceted resources implies, determining precisely how the desired enacted curriculum should look for purposes of assessing fidelity would be a complicated endeavor.

The conception of curriculum materials as artifacts or cultural tools proposed by Brown (2002) goes a step further, in that it frames both materials and teachers as active players in an interactive relationship. As readers, teachers draw on their personal resources to understand and bring meaning to the offerings provided in the curriculum. Simultaneously, prepared curricula contain material and representational resources laden with subjective meanings that mediate teachers' reading of them. This outlook helps to explain research findings in which teachers both construct their own understandings of curriculum components and are influenced by them.

The four principal constructs of the framework are (a) the teacher, (b) the curriculum, (c) the participatory relationship between them, and (d) the resulting planned and enacted curricula. Its design is grounded in two assumptions central to the previous account of teaching: that teaching involves curriculum design and that it is multifaceted. Together, these stances imply that teachers are engaged in design work throughout the multiple domains of teaching. Emphasizing the relationships among the participatory relationship, the planned curriculum, and the enacted curriculum allows the framework to represent the cycles of design before, during, and after classroom practice. Like Brown's (2002) Design Capacity for Enactment framework, this framework accentuates what I refer to as the participatory relationship, the interaction between the teacher and the curricular resource.

It also shows that the interaction is shaped by what the teacher and the curriculum bring to them. The following discussion is structured around the four principal dimensions of this framework and their implications for future research.

The Teacher

The left-hand circle of the framework represents the resources, stances, and perspectives that the teacher brings to the participatory relationship with curriculum resources. These include the individual characteristics discussed in the literature reviewed earlier, such as knowledge, capacities, beliefs, perceptions, and experiences. While we know a great deal about many of the teacher characteristics and resources that influence teaching and curriculum use, such as beliefs and knowledge, others merit further study. Still other characteristics are yet to be identified. Characteristics that relate specifically to teachers' interactions with curriculum, such as the teacher's perception of and stance toward curriculum materials and the teacher's professional identity as it relates to the use of curriculum resources, are of particular relevance because they are examples of influential factors in teacher–curriculum relationships that respond directly to the curriculum as a subjective scheme. The field would benefit from continued research on individual teacher characteristics and the ways that they contribute to, shape, or constrain teacher–curriculum interactions. Such research could also help answer critical questions about this relationship: To what extent and in what ways is the influence of these characteristics consistent across different curriculum materials and teaching contexts? How do these characteristics change through use of particular materials or other mediating experiences?

The Curriculum

The right-hand circle represents the particular curriculum resource or text being used. The outer ring denotes the curriculum as a subjective scheme—how the curriculum, its particular features, and curricula in general are perceived by the teacher and within the broader society. These schemes serve as a backdrop within which the objectively given structures (Otte, 1986), represented in the inner ring, are encountered. Because we know so little about the curricular features that figure into the teacher–curriculum interaction, the items in this circle are more tentative than those in the teacher circle.

As previously mentioned, analyses of curricula tend to emphasize structural components, such as mathematical content and pedagogy. Brown's (2002) triad—representations of objects, tasks, and concepts—illustrates this approach. Descriptions offered by Herbel-Eisenmann (2000), Love and Pimm (1996), Otte (1986), and Remillard (2002) focus on features of materials not directly related to content that are subtle and often unintended. These include voice and look as well as structure. This area merits continued exploration, particularly in the case of curriculum materials that are substantially different from traditional curricula in structure, look, and intent. Although it is important to continue to examine teachers' responses to the new ways of organizing mathematics content and supporting students' learning that are provided in *Standards*-based curricula, it is equally important that researchers consider the role of features not directly associated with the content or pedagogy of the curriculum. To what extent and in what ways do features such as voice and look matter in the teacher–curriculum interaction?

Participatory Relationship Between Teacher and Curriculum

The participatory relationship between the teacher and the curriculum consists of interactions in which both the teacher and the curriculum are significant and active participants. The notion that curriculum can be an active participant in these interactions is based in sociocultural perspectives on cultural artifacts or tools as previously discussed. Sherin and Drake (2004) and Remillard (1999) include ways of reading, evaluating, and interpreting in their analyses of this relationship. Brown (2002) identified ways of using curricula—offloading, adapting and improvising—that also fit into this category.

It is important to acknowledge that what the teacher and curriculum bring to this participatory relationship must be understood as embedded in particular local and global contexts. However, the influence of the context is particularly apparent when examining this interactive relationship. As is indicated in the framework and has been found in a number of studies of curriculum use, the teaching and school contexts influence the way that teachers engage with, read, and use mathematics curriculum materials (e.g., Keiser & Lambdin, 1996; Manouchehri & Goodman, 1998).

A primary purpose of this article is to bring attention to this participatory relationship and suggest that it needs continued examination and explication. Further research in this area can provide answers to questions such as these: When do teachers engage in these and other activities with curriculum resources? What is the relationship between particular curriculum features and the ways that teachers engage them? How does the participatory relationship change as a result of extended use of a particular curriculum?

The Planned and Enacted Curriculum

In the framework presented in Figure 3, I have differentiated between the planned curriculum and the enacted curriculum to indicate that the curriculum enacted in the classroom can, at best, be represented by the curriculum planned by the teacher. The planned curriculum is the outgrowth of the participatory interactions between the teacher and the curriculum. The bidirectional arrow signals the possibility for the planned curriculum to, in turn, influence the participatory relationship, in that it shapes what teachers seek, read, and draw on in the curriculum resource.

The enacted curriculum captures these plans as they unfold in a particular context with particular students. This is a critical dimension of the curriculum design process that takes into account context-specific demands as they emerge. In other words, the enacted curriculum is co-constructed by teachers and students in a particular context. Several researchers have identified the improvisational and adaptive nature of this work (Borko & Livingston, 1989; Heaton, 2000; Remillard, 1999; Yinger, 1987), highlighting the tendency for the enacted curriculum to represent minor or substantial changes in curricular plans. Yet we have yet to determine whether a consistent relationship exists between the planned and enacted curricula across a large sample of teachers. Do teachers tend to make predictable adaptations in their plans when enacting them in the classroom? What curricular, contextual, or teacher factors influence these adaptations? This framework also raises questions about possible relationships among the participatory relationship, the planned curriculum, and the enacted curriculum.

Although the primary process captured by the framework in Figure 3 is the transition from the teacher–text relationship to the enacted curriculum, it is important to note the ways in which this path is actually cyclical and dynamic, as is represented by the arrows from the enacted curriculum to other key dimensions. For instance, some teachers do not consult their curriculum resources during instruction, whereas others do. Teachers may make adaptations to their curriculum plans in the moment, which are further transformed as they enact them in the classroom (Remillard, 1999).

The framework also captures the possibility that enacting curriculum will prompt change in individual teacher characteristics (Remillard, 2000) as well as in the participatory relationship between the teacher and the curriculum (Collopy, 2003; Drake & Sherin, 2002). These arrows account for the ways that curriculum use can prompt teacher learning and change. Because few studies of teachers' curriculum use have examined the participatory relationship over time, there is still much to learn about whether use of unfamiliar curriculum materials might be viewed as a form of teacher development.

Implications for Policy and Practice

The preceding discussion raises a number of questions about current knowledge in the field of teachers' uses of mathematics curriculum materials and points to much-needed research to inform practice. At the same time, it also offers insights and perspectives that can guide current policy and practice. I conclude with a discussion of several practical implications of findings described in this review and, in particular, of the model of curriculum use proposed in the previous section.

The understanding that the process of using a mathematics curriculum guide is complex and dynamic and is mediated by teachers' knowledge, beliefs, and dispositions suggests that the decision to adopt a single curriculum in a school or district will not alone result in uniform mathematics instruction. Teachers require substantial support in learning to use new curriculum materials. They need to learn about the content, goals, approaches, and underlying assumptions of the curriculum they are being asked to use. However, information about the curriculum is not sufficient. For many teachers, the process of interacting or participating with a new curriculum is neither explicit nor public. Teachers would benefit from opportunities to read and examine a new curriculum with colleagues, making their interpretations and decisions explicit to themselves and others. A central goal of such an activity would be for teachers to openly and actively engage in participating with a curriculum guide.

As stated previously, the stance that curriculum use by teachers involves a process of transforming the written curriculum, together with the finding that curriculum resources themselves are multifaceted, troubles the notion of curricular fidelity—that it is possible to realize a precise match between the curriculum as written and as enacted in the classroom. At the same time, it would be inaccurate and irresponsible to conclude that all interpretations of a written curriculum are equally valid. Those who are involved in facilitating the use of curriculum materials are in need of ways to characterize reasonable and unreasonable variations or instantiations of a particular curriculum that are tied to features most central to its

design. The primary responsibility for identifying ranges of acceptable variation and clarifying the essential components of a curriculum belongs to curriculum developers. However, examining a curriculum to identify the ideas and suggestions that are core and those that are more superficial would be a productive activity for a community of teachers to undertake in the form of ongoing inquiry and professional learning.

The assertion that the materials themselves matter in teachers' interactions with curriculum materials also has implications for curriculum developers. As described above, curriculum materials have a number of characteristics beyond the specific mathematical content and pedagogy represented in the text. These characteristics include the look and voice of the text and its subjective scheme or how it is perceived. It is critical that curriculum developers pay careful attention to the multiple ways that their materials communicate with the teacher. They must consider how they are addressing the teacher through the design of their materials, how they expect the teacher to respond to their suggestions, and how they represent what it means to use their resource. In other words, the designers of curriculum materials, as well as those who adopt them, must carefully consider how they frame and support the teacher–curriculum relationship.

Notes

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[1] Specifically, the term New Math refers to the curriculum materials developed in the 1960s by the School Mathematics Study Group (SMSG). It is often used to refer to all reform-oriented mathematics materials produced during the curriculum reforms of the late 1950s and early 1960s.

[2] I use the term "mainstream" to refer to the textbooks that were most commonly used in schools before the mid 1990s, when *Standards*-based materials began to appear on the market. For the most part, these texts were published by commercial publishers, such as Addison-Wesley or Holt, and tended to look alike. The term "innovative" refers to textbooks and curriculum materials designed to offer alternatives to mainstream texts. These were most frequently developed by researchers and were infrequently published by commercial publishers. The term "*Standards*-based" refers to those curriculum materials designed to reflect the vision of the NCTM *Standards* (1989, 2000). My use of the descriptor is not limited to those materials developed with the support of National Science Foundation funding. Most innovative materials share common characteristics with *Standards*-based materials, but this is not always the case. *Standards*-based materials might be labeled as a particular class of innovative materials. When necessary, I use the term "traditional" to refer to materials that reflect a view of mathematics teaching and learning that has become a tradition in the United States. This view is characterized in the 1989 NCTM *Standards* and is identified as an approach in need of rethinking. As *Standards*-based curricula become increasingly available and the ideas promoted by the NCTM *Standards* gradually make their way into U.S. classrooms, the term "mainstream" has become a problematic and unclear descriptor and the term "traditional" seems to be a better choice.

[3] This group began its work in 1988 on a study of the relationship between state-level mathematics policy and classroom practice in California. Later, in 1992, as it expanded its focus to include three states and policy in two subjects (mathematics and reading), the group took the title EPPS.

[4] Because the focus of this article is examining conceptual issues guiding research on curriculum use, findings from these studies are not discussed here. Stein, Remillard, and Smith (in press) discuss research on factors that influence teachers' interactions with curriculum materials, including teacher resources, curricular resources, and context.

[5] It is worth noting, however, that recent district and school policies continue to rely on this approach.

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