How Subjects Matter in School Leadership

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In the world of instruction and learning, it is now widely recognized that the subjects matter (Stodolsky, 1988). For example, students' capacities to learn are related to their prior knowledge in particular subject matter domains (Glaser & De Corte, 1992) and their development of understanding is deeply related to the epistemologies of specific subject matters (Greeno & Goldman, 1998; Johnston, 1999). Similarly, teachers' dispositions toward and knowledge of the subjects they teach exerts a strong influence on the quality of instruction they provide (e.g., Brophy, 1991), so strong in fact that subject matter knowledge has been called the missing paradigm in research on teaching (Shulman, 1986).

Most conceptions of educational leadership, however, continue to be rooted in policy and organizational analyses that pay little, if any, attention to instructional theory or, if they do, treat instructional practice as a generic enterprise. A responsible reply to recent calls for more instructionally relevant models of school leadership must face the analytic and pragmatic challenges of making subject matter visible in and useful to theories of school leadership.

The school subject matters with which we concern ourselves in this paper are mathematics and literacy for grades K – 5. Viewed as the core of primary education, these two subjects comprise the largest amount of instructional time in American elementary schools. Although most adults view mathematics and literacy as drawing upon very different sets of knowledge and skills, the specific ways in which they differ and the influence of those differences on the delivery of instruction and the organization of schools and districts has been little studied. The few studies that have addressed the intersection of subject matter and the organization of schooling have been based on secondary teachers'

perceptions of the features of various subject matters (Stodolosky & Grossman, 1995) or have examined the resources that are typically available to support teacher learning in mathematics vs. literacy (Price & Ball, 1997).

The purpose of this paper is to examine the role of subject matter in school- and district-wide reform, efforts in which the goal extends beyond individual classrooms to broad-scale improvement. We take as our point of departure differences in what it means to know and do mathematics and literacy and then explore the implications of those differences at the levels of classroom practice, teacher professional development, and, finally, administrator practice. Gradually, we build an argument for the need for administrators to possess subject-matter-specific knowledge in order to successfully guide and support reform.

TOWARD A SUBJECT-MATTER-SPECIFIC VIEW OF LEARNING AND LEADERSHIP

In the early 1970s, as cognitive psychologists began to examine the ways in which students grapple with complex problems, they discovered that learning was subject matter specific rather than generic. The subject specificity of learning is related to the fact that students bring to the learning situation preconceptions and prior ideas that are more or less helpful to the material-to-be learned (Bransford, Vye, Adams, & Perfetto, 1989; Glaser & DeCorte, 1992; Voss, 1989). In addition, as revealed by studies on the social and participatory nature of learning, ways of thinking, reasoning, and communicating are often unique to particular subject matter domains.

In the 1980s, instructional researchers began to frame their work in subject-matter specific ways as well, reasoning that effective teaching involves (a) organizing the *content* of instruction in terms of the relationship between the to-be-learned material and students' prior knowledge; and (b) organizing the *processes* of instruction in ways that are harmonious with subject-matter specific ways of thinking, reasoning, and communicating.

Hence, subject-matter influences began to be felt in emerging models of effective instruction in terms of both *what* was taught and *how* it was taught (Brophy, 1991).

These models gained considerable currency and exposure from the release of professional standards for teaching practice in the late 1980s and early 1990s (e.g., the National Board of Professional Teaching Standards[1994] and NCTM's *Professional Standards for the Teaching of Mathematics* [1991]). A common feature shared by these standards is the characterization of effective teaching as specific to particular subject matters. Moreover, these standards note the importance of socializing students into the language, modes of discourse, and activities associated with the various subject matters in addition to teaching them subject-matter specific structures and concepts. Students are viewed as learning by experiencing and practicing how knowledge is discovered and communicated as opposed to encountering it only in its completed forms, that is, as the finished product presented in many textbooks.

This view of teaching and learning as deeply intertwined with the ideas and ways of knowing in various subject areas, suggests that identifying generalizations about classroom practice that transcend subject matter will only take one so far. With respect to mathematics and literacy, for example, the unique features of what constitutes competence in these two subject areas should color the content and processes of effective instruction.

What are some of these unique features? Although occupying the same privileged position as core elementary subject matters, literacy and mathematics do not share the same academic heritage: Mathematics is firmly situated as a discipline within higher education; literacy is not. Although school subjects are not synonymous with the academic disciplines, they do share many of their attributes. Thus, compared to school literacy, one can expect school mathematics to possess tighter connections with a definable disciplinary approach—that is, a delineated network of concepts, an established method of inquiry, acceptable techniques for acquiring and verifying findings, an agreed-upon symbol system, and a standard vocabulary (Gardner & Boix-Mansilla, 1994).

Close connections between the disciplinary approach of mathematics and school mathematics plays out in a number of ways. First, school mathematics is comprised of a definable body of knowledge, a structure of interrelated concepts, a symbol system, and a vocabulary that—although not synonymous with—is derived from the discipline of mathematics. Second, in recent years, school mathematics has expanded to include the experience of creating and using mathematics, not simply memorizing facts and repeating routine calculations. This aligns with current ways of viewing mathematics as an inherently social activity in which a community of trained practitioners uses the tools of abstraction, representation, and symbolic manipulation to engage in the study of patterns, to solve problems, and to create new undertandings (Lakatos, 1976). Viewed in this way, mathematics—both disciplinary and school mathematics—goes well beyond knowledge of facts, concepts, algorithms, or definitions. What counts as knowing and doing mathematics also includes using tools in the service of creating, communicating, verifying and applying mathematical concepts and structure (Schoenfeld, 1992).

Compared to elementary school mathematics, elementary school literacy has much less of a delineated knowledge base through which to proceed. Although the "content" of literacy has been variously defined as the grammatical and linguistic structure of written and spoken language, children's literature, phonics, and/or the writing process, the sum total of these does not represent "disciplinary knowledge" in the classic sense of the term. Rather the content of school literacy is dispersed among several frames of understanding and at least three academic disciplines (language, literature, and composition). It has even been argued that school literacy be conceived of as intellectual development writ large (e.g., Johnston, 1999). These multiple and diverse perspectives on what should be taught under the banner of school literacy suggest the need to conceptualize its foundation differently from the singular disciplinary underpinning that we have identified for school mathematics.

The activity of *learning to be* and *being literate* also has different roots for school literacy. In mathematics, we noted similarities between "doing mathematics" in school and

the activity of practicing mathematicians. Lacking a single disciplinary home comparable to that noted for mathematics, school literacy has looked more broadly for models of literate practice. Ideas about what constitutes literate practice have been based upon models of knowing in literature, as well as methods of inquiry in a variety of other disciplines such as science and history. Even within literature, however, there is no one agreed-upon method for reading and interpreting text. Rather, the method one uses depends on the academic community with which one identifies. These diverse underpinnings suggest that what "counts" as being literate and doing literacy-based practice is multidimensional, elusive, and not easily pinned down.

Despite these differences, recent "reform" approaches to school mathematics and literacy classrooms share a common philosophy regarding how students learn. In both subjects, emphasis has shifted from student as receiver of a finished record of knowledge to students as active constructors and interpreters of knowledge. In mathematics classrooms, this takes the form of students actively making sense of mathematical puzzles and patterns, devising their own conjectures and seeking to prove or disprove them, and, together with their classmates, developing shared norms for what counts as mathematical knowledge. In literacy classrooms, it takes the form of students writing their own texts for particular purposes and to significant audiences, offering and defending their own interpretations of other authors' texts, and learning to participate in a community of readers engaged in literate discussions.

These similar beliefs regarding how students learn are associated with what appear to be, on the surface at least, a congruent set of recommendations regarding pedagogy. Teachers are urged to lecture less, to ask fewer factual questions, and to push student thinking through "higher-order" questions—questions that require extended student reasoning and explanations. Rather than having all classroom talk filtered through and judged by the teacher, teachers are encouraged to help students learn how to talk to and critique one another's' responses. In general, the role of the teacher—in both literacy and

mathematics classrooms—has changed from dispenser of knowledge to engineer of "learning environments" and orchestrator of classroom discourse.

Underneath these surface similarities, however, differences between the activities of doing mathematics and literacy lurk. What constitutes an authentic task is different in literacy vs. mathematics, as are answers to questions such as: What counts as knowledge? How is new knowledge created and justified? What constitutes an acceptable kind and source of evidence for supporting a claim? Questions such as these can be masked by the common commitment of both literacy and mathematics reformers to active student learning and inquiry-based pedagogy. In this paper, we argue that such questions—questions that have their roots in the unique foundations underlying school mathematics and school literacy—are profound and relevant questions for teachers' classroom practice, and ultimately for the professional developers who assist teachers, and even for administrators who must guide and support reform initiatives.

Implications for Teacher Professional Development

Professional development that aims to move teaching practice beyond basic skills and toward content that requires analytic reasoning and problem solving requires an underlying rationale that goes beyond influencing teaching behaviors (Kennedy, 1998). The design of such professional development must include attention to teacher knowledge, including (a) the kind of knowledge that teachers need to teach reform pedagogies; and (b) the knowledge and beliefs possessed by teachers' with whom one is currently working. Just as students' current proficiencies need to be gradually brought into alignment with what they should know and be able to do, so, too, do teachers' current capacities need to be brought into alignment with the knowledge and skills needed to teach in these new and demanding ways.

Kind of knowledge needed

It has been suggested that both substantive knowledge of the discipline and orientations to the discipline are important elements of the knowledge base needed for teaching (Schwab, 1962). *Substantive knowledge* refers to the topics, procedures, and central concepts of the domain. In mathematics, substantive knowledge refers to propositional and procedural knowledge of mathematics, knowledge of mathematical structures, and relationships among structures, concepts, and procedures (Ball, 1991). The diffuse and large knowledge base undergirding school literacy makes it much more difficult to define the substantive knowledge needed by teachers of literacy (Grossman, 1991). If one confines the discussion to literature, it would include knowledge of literary themes such as plot, character development, genre, and so forth. However, as noted earlier, the relevant knowledge base for school literacy also includes the grammatical and linguistic structure of written and spoken language, phonics, the writing process, and even content associated with other disciplines such as history and science.

Orientation to the discipline refers to teachers' understandings and beliefs regarding how knowledge is created and verified in the discipline. In mathematics, the prominent agreed-upon stance is one which acknowledges the socially constructed nature of mathematical knowledge, but also honors an established method for creating knowledge (i.e., constructing and verifying proofs) (Schoenfeld, 1992). In literacy, there is no one accepted stance. Nevertheless, within the discipline of literature—one of the primary foundations for literacy—there are several articulated orientations toward the interpretation of text with which teachers can become familiar (Eagleton, 1983). Moreover, to the extent that teachers' literacy instruction bleeds into other disciplinary areas such as science or history, there are established "ways of knowing" in these other disciplines with which teachers can become acquainted.

Research suggests that both of the above kinds of teacher knowledge—substantive knowledge and orientation to the discipline—directly influence the decisions teachers make

in the classroom. For example, Ball (1991) has shown how teachers' beliefs about what counts as mathematical knowledge and who gets to make it and make sense of it influences the tasks they choose and the kind of discourse they apprentice their students into. Similarly, Grossman (1991) has shown how teachers' stances toward literary interpretation influence their goals, curricular choices, instructional assignments, and questions.

Knowledge typically possessed by elementary teachers.

Research suggests that—in general—elementary teachers view themselves as competent readers and writers, but feel less capable with respect to mathematics (Ball & Cohen, 1995). Not only is their *substantive knowledge* of mathematics (knowledge of topics, procedures, and concepts) fragile, but most practicing teachers learned mathematics themselves at a time during which it was taught primarily in a procedural manner, thereby leading to an *orientation* in which mathematical truth is indisputable, and the role of the teacher is to teach it and the role of the student is to practice and memorize it (Ball, 1987). This stands in sharp contrast to current reform models in which teachers are encouraged to instruct from the stance that mathematical knowledge is constructed and that the role of the teacher is to assist students to develop and justify mathematical claims.

The above differences with respect to what teachers *need* to know and what they typically *do* know in mathematics vs. literacy have implications for the way in which professional development tends to be designed. Because it is widely recognized that many elementary teachers need to deepen their substantive knowledge of mathematics, a great deal of effort has been devoted to the design of professional development that engages teachers as learners of mathematics themselves. This kind of professional development has the added advantage of providing teachers with the opportunity to make sense of mathematics in a community of mathematical learners, thereby challenging the more procedurally based orientation toward mathematics that most practicing teachers bring with them to interpreting the new reforms.

In contrast, the (often unstated) assumption that teachers possess the substantive knowledge required to enact literacy reforms coupled with the diffuse knowledge base undergirding school literacy has discouraged attempts to design professional development that focuses on substantive knowledge. Similarly, the kinds of communities in which literacy teachers should participate have remained underspecified. In this paper, we argue that, just as in mathematics, attempts should be made to define the substantive knowledge that teachers of literacy must possess (e.g., knowledge of phonics, word structures, children's literature) and the discourse communities in which they should participate—communities that would provide models of an appropriate range of literate practice.

Implications for Leadership

The need for educational administrators to become instructional leaders has recently gained considerable currency. However, research which simply identifies what effective instructional leaders "do" will be insufficient to guide the needed shift from administrators as building managers to administrators as leaders of the intellectual agendas of their districts and schools. Concomitant attention must be paid to the cognitive underpinings associated with the capacity to guide instruction—foremost among which are the knowledge bases and dispositions toward learning possessed by individuals who effectively lead in this area.

Researchers have begun to identify the cognitive underpinnings that educational leaders need to possess in general (Hallinger, Leithwood, & Murphy, 1993) and with respect to instructional leadership in particular (Rowan, 1995). Although such work has begun to draw upon cognitive research regarding how individuals learn in complex domains, to our knowledge, the subject-matter-knowledge needs of school leaders has not yet been addressed (see Nelson & Sassi, 2000, for an exception).

The premise of this paper is that effective administrative leadership for reform must be knowledgeable about and sensitive to both the similarities and differences in teaching

and learning in the various subject matters, especially—given the preponderance of reforms in mathematics and literacy—to the similarities and differences between these two subject areas. In order to provide intellectual leadership for instruction, principals and superintendents must understand the manner in which classroom practices and curricular programming differ in mathematics vs. literacy, as well as the different needs that teachers have with respect to each subject area. Only then will they be able to wisely select among the plethora of professional development programs, to evaluate the quality of instructional programs and practices, to validly select and interpret the results of student assessments, and to steer building-wide reforms that span various grades.

In this paper, we argue that all administrators who profess to be instructional leaders—superintendents, deputy superintendents, and principals—must have some degree of understanding of how instruction and learning differ in various subject areas. In this regard, the intersection between that subject matter knowledge and the managerial knowledge required of all school administrators constitutes a unique form of knowledge needed by school and district leaders. Following Shulman's taxonomy of kinds of subject matter knowledge needed for teachers, we call the form of knowledge needed by administrators "leadership content knowledge."

METHODS

Research Context

We use Community School District #2 in New York City as our research site. District #2 espouses a model of school improvement based on the phasing in of instructional change by content area. District leaders began to implement their improvement strategy in the area of literacy. Eight years later, with a district-wide program of literacy well on its way, the district began to mobilize its efforts in the area of mathematics.

In District #2, reform has meant—indeed it has demanded—that supervisory administrators (i.e., the district superintendent, deputy superintendents, and principals)

participate in instruction up close, that is, inside the classroom door. As part of the literacy initiative, for example, principals are expected to understand, to support, and to evaluate the quality of instructional practice in individual teachers' classrooms. Classroom practice exists in a shared, public space. It is an object of discussion and reflection—a site for continued learning and growth. Moreover, professional development is viewed as everyone's job, not only that of staff developers or specially hired consultants, but also of principals and district administrators (Alvarado, 1998).

These practices contrast sharply with most districts in which classroom practice is the responsibility of the classroom teacher alone and where professional development remains disconnected from teachers' day-to-day practice and from supervisory administration. The close connections that District #2 principals and district leaders have to classroom practice make it a particularly rich site for examining the infusion of subject matter into educational administration.

Data Sources and Analysis

This study is part of an ongoing research and development project (the High Performance Learning Communities Project, 1996-2001) that seeks to understand, support, and disseminate the work of Community School District #2. The data described below form the core of the information analyzed and reported on this paper, but they were strongly informed by previous project research and its associated wider data set.

Data for the present study were gathered through observations, interviews, and review of documents. Observations were conducted of 6 professional development sessions across the two subject areas. In addition, 9 teachers spread across 3 elementary schools were observed for 4 complete days of instruction (for a total of 36 observed instructional days). Seventeen interviews were conducted with principals, staff developers, and teachers in these same three schools. The topics covered included the mathematics, literacy and standards initiatives with a particular focus on differences between mathematics

and literacy. Finally, interviews were conducted with district leaders associated with each initiative and documents associated with their mathematics and literacy programs were reviewed.

The data have been analyzed with respect to three analytic lenses corresponding to each of three spheres of influence. In the first section, we review the instructional practices associated with the district's mathematics and literacy programs. How do differences in what it means to know and do mathematics and literacy show up in these instructional programs? In the next section, we examine the manner in which differences in these two subject matters have an impact on professional development for teachers. In the final section, we turn to an analysis of how administrators' practices turn on differences between mathematics and literacy. We conclude with a discussion of why and how multiple subjects should matter in emerging models of educational leadership.

HOW THE SUJBECTS MATTER IN THE CLASSROOM

The programs which provide the foundation for District #2's literacy and mathematics initiatives are the Balanced Literacy program and TERC's *Investigations* curriculum. Balanced Literacy is a literature-based program for teaching children to read and understand text. In the early grades, reading strategies based on pictorial, semantic, and phonetic cues are explicitly taught. Later, emphasis is placed on developing student's ability to interpret and critically analyze text. The *Investigations* curriculum is one of several curricula recently developed with National Science Foundation funding to address the need for school mathematics programs to follow the guidelines of the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards* (1989). It stresses the understanding of mathematical concepts and procedures plus the development of students' capacities to think, reason, problem solve and communicate mathematically.

The Balanced Literacy program and the *Investigations* curriculum are compatible in a number of ways. Both are challenging, high-level programs which feature cognitively

rich tasks that require sustained effort, nuanced judgment and self-regulation to complete. The tasks often require that students access and use relevant prior knowledge, grapple with unfamiliar material, and/or engage in complex reasoning (e.g. interpreting character motivation, making connections to other texts, developing mathematical generalizations, identifying the mathematical strategies which are most efficient for a particular problem). This emphasis on high-level reasoning and understanding can be viewed as the hallmark of both programs.

Both programs also aim to integrate the building of basic skills with the development of higher level forms of thinking, reasoning, problem solving, communication, and comprehension. Rather than assuming that high-level forms of student engagement must wait until students have attained complete mastery over basic skills, both programs encourage students to engage in deep thinking *as* they learn basic skills. Even kindergarten students just beginning to learn the print-to-sound code are encouraged to engage in thoughtful discussions of books which are read to them. Similarly in mathematics, kindergarten and first-grade students are asked to identify patterns and make generalizations, even as they are just learning to add single digit numbers.

Another similarity between the two programs is the manner in which they connect to students' lives by providing tasks that appeal to their personal interests and developmental needs. In the literacy program, books are selected not only for their ability to offer productive intellectual challenges to the students, but also for their relevance to the students' lives and interests. Similarly, *Investigations* "projects" are designed to get students involved a range of simulated activities such as building cities, taking surveys, plotting class journeys on maps, and designing toys. Students collect and share data brought from home and are often asked to use "real stuff" from their communities in their investigations—things such as menus from local restaurants or maps from the community.

Finally, the culture of the classrooms that teachers aim to develop in both mathematics and literacy is similar. In each case, teachers aim to create in their classrooms a

community of learners who take responsibility for discussing and building new knowledge. During classroom discussions students are encouraged to respect and build on each others' contributions, challenge each others' reasoning when appropriate, take risks, and view mistakes as opportunities for learning.

Despite these similarities, the unique aspects of what it means to know and do mathematics and literacy contribute to important differences in the programs and their recommended instructional practices. These differences are discussed below.

Specification of the Content-to-be-Learned

We have identified a number of differences between the *Investigations* curriculum and the Balanced Literacy program with respect to recommendations regarding *what* should be taught during the elementary grades. In the Balanced Literacy program, the content is so large that it defies attempts to outline, structure, or place boundaries around it. Indeed, it often bleeds into other disciplinary-based school subjects such as science, even in the primary grades. In addition, the identification of content for the literacy program has been hamstrung by debates regarding what constitutes the "correct" content to be taught. Is it the traditional Western European canon? To what extent and how should competing legacies be represented?

Consequently, the Balanced Literacy program does *not* specify what content should be learned. Rather the specifications provided by the program attend to instructional *forms* (i.e., Shared Reading, Guided Reading, Independent Reading, and Read Alouds)and reading *strategies* (i.e., strategies for deciphering unknown words and for interpreting the meaning of text). Specific content, such as which books to read or a scope and sequence for phonetic competence are not identified, much less organized in any particular order. Thus, in the Balanced Literacy program teachers need to make their own choices about which topics to cover and when.

Taking its cues from the national standards for school mathematics (NCTM, 1989) which, in turn, have been shaped by the discipline of mathematics, the *Investigations* curriculum, on the other hand, does specify the body of mathematical knowledge that elementary students should learn. *Investigations* provides a specific set of topics to be covered, tasks for students to do when covering those topics, and a general sequence for those topics. The curriculum is divided into grade levels with each grade level being divided into a number of units. Within each unit are a series of investigations which are "designed for use as a cohesive block rather as isolated projects" (Russell, et al., p. 5). Overall, then, the *Investigations* curriculum has a defined, organized and structured feel to it. The mathematical ideas that students should master are systematically laid out; other than some flexibility in sequencing, teachers have few choices regarding what to cover and when.

The differences in content specification between literacy and mathematics relate to another importance difference: The means for assessing and building upon students' current knowledge and proficiency differs in the two programs. District #2's Balanced Literacy program is described by district leadership as *assessment driven.* Instructional planning is based upon continuous assessment, both formal and informal, of students' reading and writing performance and a significant amount of class time is devoted to students working on tasks that are specifically tailored to their levels of knowledge and proficiency. In contrast, *Investigations* can be seen as *topic driven.* Instructional planning is guided by the content to-be-learned and most of the instructional time is devoted to activities in which students are all working on the same task. During the 36 days of instruction observed, approximately, 61% of the time spent in literacy instruction was devoted to individualized activities, whereas only 14% of the mathematics instructional time was devoted to individualized activities.[1]

[1] The mean amount of time devoted to literacy per day was nearly twice as long as the mean amount of time devoted to mathematics per day (124 minutes vs. 56 minutes). Consequently, the absolute amount of

While assessment is highly specified component of the Balanced Literacy program, less specificity surrounds the instructional implications of student assessment. Indeed, the capacity to make instructional decisions based upon assessment information has been cited as a weakness of teachers' practice. In general, the Balanced Literacy program recommends using the results of assessments to select appropriate books for Independent Reading and for the assignment of student to Guided Reading groups.[2] Beyond guidance on how to remediate obvious deficits, however, the next to-be-learned skill or concept remains underspecified. District leaders often speak of taking students "to the next level," but rarely specify what constitutes that next level.

In contrast, within the *Investigations* curriculum the next skill or concept is always there waiting to be taught. As described earlier, the curriculum is divided into modular units, each of which revolves around a set of two or three related areas. Thus, all students are studying the same set of ideas at the same time and working on the same tasks at the same time. The concern with *Investigations* is the opposite of the concern in the Balanced Literacy program: teachers feel the need for more guidance on how to assess students' levels of mathematical proficiency and how to tailor their lessons to different student proficiencies.

The *Investigations* curriculum provides some suggestions for tailoring the instruction to particular student needs, including changing the numbers in a problem to make the problem more accessible or more challenging for particular students, repeating activities with which students need more experience, and rearranging the composition of pairs or small groups so students learn from a variety of their peers. In addition, some teachers attempt to provide individualized instruction for students through the use of games

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time spent in individualized activities in literacy is **far** greater than the absolute amount of time spent in individualized activities in mathematics.

[2] Guided Reading groups provide the opportunity for similarly challenged students to participate in lessons specifically geared to their needs.

and other activities that students do alone or in small groups to practice what they've learned in whole-class lessons.

In general, though, *Investigations* tends to emphasize *building on students' thinking in relation to the task-at-hand,* rather than providing different tasks for different students. In this regard, the multi-dimensionality of the instructional tasks becomes important. Most tasks have been designed to allow multiple entry points and to be solved using more than one solution path. As such, most students can work on the task as some level. The mark of good teacher is her ability to understand the way in which the student is attempting to make sense of the task and then to scaffold the student to more sophisticated, correct, and efficient ways of thinking about the task.[3]

Styles of Reasoning into which Students are Socialized

A key role of teachers in the new reforms is to initiate and guide productive forms of student discourse. Discourse ultimately entails fundamental issues about knowledge: What make something true of reasonable? Who gets to ask questions and evaluate answers? What counts as an acceptable question and answer? How can we figure out if something makes sense? (NCTM, 1989). In the new reforms in both literacy and mathematics, students are being apprenticed into a kind of thinking that privileges intellectual coherence and active knowledge building over finding the correct answer.

In both the Balanced Literacy program and the *Investigations* curriculum, teachers are encouraged to lead classroom discussions in which students listen to one another, build upon one another's ideas, make reasoned arguments, and support their comments with evidence. Although district leaders have stressed similarities between discussions in literacy

[3] The above differences in level of content specification and individualization of the mathematics vs. literacy programs are sometimes summed up as "teaching the child" (literacy) vs. "teaching the curriculum" (mathematics). We think this is an oversimplification. Good instruction scaffolds students' ability to grapple with and make meaning of important and complex ideas. Instruction can suffer from an overemphasis in either direction. Too much technique surrounding assessment of individual students often leads to a mechanized view of learning and less meaningful engagement with deeper, harder-to-grasp ideas; too much emphasis on the curriculum, however, can lead to losing track of individual students' trajectories with respect to acquiring the big ideas embedded in the curriculum.

and mathematics, we have identified differences in the nature of the classroom discussions in these two subject areas—differences that have implications for ways in which talk is orchestrated and guided. Consider the following two examples from our classroom observation data:

> A fourth grade teacher is in the midst of a unit on the mathematical concept of symmetry. She begins the lesson by noting that there was a great deal of disagreement in students' responses to the homework which asked students to identify whether or not the letters of E, D, Z, Y, H, T, M, and Q are symmetrical or asymmetrical. After giving students a few minutes to discuss their ideas about each letter with their partners, she opens up the discussion to the whole class. She begins with the following statement: "If you think some of the letters are asymmetrical, raise your hand." About two-thirds of the students raise their hand. *There appears to be no concern among the students (or by the teacher) that students have different viewpoints on this*, *suggesting the existence of classroom norms that students can and will disagree with one another and that they expect to be held accountable for providing justifications for their claims.*
>
> Lisa is called upon to choose one letter, state whether it is symmetrical or asymmetrical, and then present her reasoning. On the blackboard, Lisa writes the letter, "T" and draws a dotted line, top to bottom along the vertical center line, claiming that the letter can be cut in half on the dotted line and therefore is symmetrical.
>
> Many hands shot up, apparently in disagreement. Hannah is called upon: "I respectfully disagree with Lisa," she says and goes on to explain that the mid-line in the T is too thin to cut in half and therefore the T cannot be divided evenly, and can't be considered symmetrical.
>
> At this point, another student, Keith, suggests that you can write the letter T as a "bubble letter" and then you can see that "it can be split." Kevin offers that it doesn't matter how thick the line is. Nora joins in, saying that she "respectfully disagreed" with Hannah, claiming that the T could be cut in half with a really sharp knife.
>
> At this point, the teacher goes to the blackboard and makes each of the letters "thicker." But one student, Rachel, continues to be hung up on whether or not the T could be cut in half. The teacher asks, "is it *possible* to cut it in half?" and Rachel says, "I guess." Sensing Rachel's continuing doubt, the teacher introduces another familiar representation to think with: pattern blocks (wooden shapes designed to represent two-dimensional geometric figures; the students had been working with pattern blocks the previous day.). The teacher asks: "Although you can't fold[4] pattern blocks in half, are they symmetrical?" She asks, for instance, is the hexagon pattern block symmetrical. A few students reply, "yes."

[4] Folding is another kind of action that can be taken to create symmetrical halves.

> At this point, the teacher says that the group needs to develop a definition for symmetrical. She suggests, "If you know it *could* be cut evenly in half, that might be our rule for identifying something symmetrical." When she asks for a show of hands again as to whether or not the T is symmetrical, almost all hands are raised. She doesn't say who is right or wrong. She says "Most of you think it's symmetrical; a few still want to think about it. "

The *content* of this discussion can be seen as highly specific and focused. All of the conversational moves centered on the same topic: the mathematical concept of symmetry. In this way, the concept of symmetry provided something toward which the conversation tracked. Indeed the teacher's goal was to bring students' understandings of symmetry and how it is determined in line with the commonly accepted mathematical concept of symmetry.

The style of reasoning, however, was by no means a straight line toward the mathematical definition of symmetry. In fact, the complete and formal definition of symmetry did not appear during this discussion. Instead of telling the students the formal definition for symmetry and asking them to memorize and apply it, the teacher steered the students toward their own construction of a set of rules for determining if something is or is not symmetrical. The process by which they did this—by putting forth claims and defending them, by challenging the claims of others, and by selecting and inventing representations with which to think and communicate—parallel the processes which practicing mathematicians use to build and verify new knowledge.

Later in the year, this same fourth-grade teacher conducted the following discussion after reading Chapter Two of *Harry Potter and the Sorcerer's Stone* aloud to her class.

> The teacher began by giving her students a few minutes to talk to their partners about the book's main character, Harry. Then she asks the entire group for comments about Harry. Lots of hands fly up. The teacher calls on Mark who says that he thinks that "Harry, the snake, and the people are all from another realm." The teacher asks him for evidence that the snake is from another realm. Mark replies, "the vanishing mirror," which refers to an event in the text during which the glass front of a boa constrictor's tank in the zoo simply vanishes. Another student (Isabel) offers that she doesn't think that the people (individuals that Harry sees on the street that he imagines know him) are magic. Then, the following exchanges ensue:

Keith: His aunt and uncle are mean to him.

Nora: I think Harry might be the narrator.

John: The snake doesn't necessarily have mental powers; that's Harry.

Rachel: I think whatever Harry thinks actually happens.

At this point, the teacher stops the conversation and says that she wants to go back to Nora's comment. She asks the class, "What does it mean to say that Harry might be the narrator?"

Hannah: It sounds like he could be.

Teacher: What is the narrator? Think about Kenny in the last book that we read.

Hannah: I think he's kind of telling it . . .

Karen: If the narrator was Harry, the story would be in first person.

Teacher: Can you explain what you mean?

Karen: We hear Harry talking like the other people.

Britt: I disagree with Isabel. Maybe the snake doesn't have powers, but I think the people do, and I agree with Rachel, because Harry wanted his hair to grow back and it did.

The conversation continues, as different students remark on who they think does and does not have magic powers. Finally, the teacher says, "We have several balls in the air: Who is magic? Who isn't magic? What kind of magic is it? But, she said, they need to "put it to rest" for now.

The *content* of this discussion was less specific and focused. With at least three lines of conversation in motion (i.e., the characteristics of Harry Potter, which characters are magical, and what a narrator is), the discussion hopped around more than the mathematics discussion. In addition, there was not a clear sense of where the conversation was headed—of a specific destination that the teacher had in mind for the discussion.

However, the style of reasoning was, in some ways, similar to the mathematics discussion on symmetry. In particular, the teacher did not tell students what or how to think about Harry, the main character of the book. Instead she appeared to be steering the students toward their own construction of ideas regarding Harry. Moreover, students went

about constructing their understandings of Harry in (at least superficially) a similar way as they constructed their knowledge about symmetry in the mathematics discussion, that is, by making claims and defending them and by agreeing or disagreeing with the claims of others.

Does this mean that the two discussions are completely parallel? No. Although the teacher adopts a similar stance *vis-a-vis* the socially constructed and disputable nature of knowledge, the discipline of mathematics—albeit the socially constructed discipline of mathematics—constrains the acceptable moves in the mathematics discussion in a way that moves are not constrained in the literacy discussion. First, the content-to-be learned is more identifiable and agreed upon, meaning that the discussion can be more focused. Second, students ultimately must learn not only that mathematical knowledge is constructed, but that it is constructed according to an agreed-upon set of rules, an established method of inquiry. As students develop identities as makers and users of mathematics they also must learn these rules and use them appropriately to prove or disprove their claims. One of the rules implicitly at play in the symmetry discussion was that the students' decision regarding what counted as being cut in half had to be consistent across all objects.

In literacy, on the other hand, the lack of a singular disciplinary home means that ways of knowing and rules for knowledge building are not as clear cut. Indeed they may—and usually do—vary depending on the community in which one is practicing and the situation at hand. Ways of knowing and rules for knowledge-building in science are very different from history. As noted earlier, even within the discipline of literature, what constitutes the acceptable bases for the interpretive process depends on the academic community with which one identifies.

The role and nature of evidence, more than any other aspect of classroom discourse, clearly sets apart the mathematics and literacy discussions. The justification of moves in a mathematics discussion always rests upon mathematical evidence. Although evidence is called upon to support one's interpretations of literature—as it was in the Harry

Potter discussion—the nature of the evidence that is acceptable and how that evidence is integrated into one's arguments is more variably defined. In some schools of literature, interpretation is rooted in the text itself. In others, consideration of the author and his/her background and intentions is necessary to unlock the true meaning of the text. In still other schools, interpretation rests on the subjective response of the reader to the text. Classroom discussions of text should incorporate different rules of evidence depending on the teachers' goals for the discussion and the underlying orientation that is appropriate for those goals.

In summary, we have noted both similarities and differences in District #2's literacy and mathematics programs. The key similarity is their emphasis on building students' capacities to understand deep content and to think and reason. On one level, the programs and practices used to accomplish this can be viewed as similar. Both programs are built around cognitively challenging tasks, teach basic skills in the context of high-level skills, and stress the importance of connecting to students' current levels of proficiency and socializing them into styles of intellectual reasoning in which they are held responsible for constructing their own knowledge and understandings.

At another level, however, there are important differences in the programs and practices associated with these two subject matters. These differences surfaced in two main areas: the specification of content-to-be learned and styles of reasoning into which students are socialized. The highly structured and carefully articulated nature of mathematics in comparison to the diffuse knowledge base that underlies literacy has been shown to have implications for the manner in which curricula in the two programs are delineated, organized and sequenced. It also has an influence on the manner in which students' current knowledge and understandings are brought into contact with the to-be-learned material. With respect to styles of reasoning, we have shown how the established method of inquiry in mathematics means that mathematics students must learn and follow agreed-upon guidelines for justifying their reasoning. In contrast, the range of conventions for building

knowledge in the various disciplines that underlay school literacy means that literacy students must learn to adjust those guidelines depending on the models of literary practice being enacted.

HOW THE SUBJECTS MATTER IN TEACHER PROFESSIONAL DEVELOPMENT

If subject matter is viewed as an important anchor for classroom practice, it would follow that effective professional development for teachers must also pay close attention to the content being learned in the classrooms and how it is being learned. But those who wish to assist teachers have an additional concern on their plate: interacting with teachers *as learners*. Effective teacher assistance requires the consideration of *teachers'* current levels of knowledge and skills with respect to the various subject matters and the kind of professional development that will best advance those knowledge and skills.

The literacy and mathematics programs in District #2 are supported by a strong district- and school-level commitment to professional development. Unlike other districts in which professional development is often not focused or relevant to day-to-day teaching practices, the professional development that District #2 teachers receive is focused by the literacy and mathematics initiatives and is directly geared toward helping them implement these two programs. In this section, we begin by examining District #2 teachers as knowers and learners of mathematics and literacy. We then describe similarities and differences in the district's professional development surrounding each of these initiatives.

Teachers as Knowers and Learners

Interviews with District #2 teachers and principals indicated several differences in teachers' knowledge with respect to mathematics and literacy. These are discussed below under the kinds of teacher knowledge introduced earlier: substantive knowledge and orientation to the discipline. We also include a brief discussion of teachers' informal experiences with these two subjects.

Substantive knowledge of mathematics and literacy

Most of the teachers who were interviewed expressed comfort with their command of literacy and the Balanced Literacy program. On the other hand, some teachers were quite candid about the limitations of their mathematical knowledge. Most were more willing to admit their lack of proficiency in mathematics than in literacy.

One principal questioned whether teachers needed to be more candid about their knowledge of literacy as well:

> . . . while people (district leaders) *thought* that teachers didn't know how to read and write, they *knew* that teachers didn't know how to do math. On the other hand, the truth is that the teachers really didn't know how to read and write. (N. Michaels,[5] interview, 6-10-99).

Whether or not one agrees with this statement depends on what is meant by knowing how to read and write. Is it being able to read the newspaper and write a thank you note? Or does it involve reading and interpreting more sophisticated literature and writing a persuasive argument? And how does one's knowledge of reading and writing (much of which may be tacit) need to be transformed in order to *teach* reading and writing? Previous research done in District #2 (Stein, D'Amico & Israel, 1999; Stein, D'Amico & Johnstone, 1999) has shown that, although teachers could certainly read and write, some teachers (especially new teachers) lacked an explicit command of the basic knowledge associated with the mechanics of literacy (e.g., principles of the print-to-sound code or rules of grammar) as well as a deep familiarity with children's literature. Thus, at some level, teachers may need assistance with substantive knowledge in both literacy and mathematics, but more willing to acknowledge that need in mathematics.

Orientations toward mathematics and literacy.

As described in the introduction, teachers' orientations toward mathematics and literacy refers to their understanding of the nature of knowledge in these two domains:

[5] All teachers and principals have been given pseudonyms.

What is entailed in doing mathematics and literacy? How truth is established? How are solutions justified and conjectures disproved?

There appeared to be a fairly wide discrepancy between teachers' orientations toward mathematics and the stance toward mathematical knowledge that undergirds the *Investigations* curriculum. One principal noted that the reason that many of her teachers were uncomfortable with the mathematics curriculum was that they had learned mathematics themselves in a very different way than they were now being asked to teach it. As a result, they felt *Investigations* was "not really math" and actually, in some cases, would decide to teach *Investigations* for some of the time and "math" at other times.

Another principal expressed similar concerns:

> A lot of teachers don't feel comfortable as mathematicians themselves. And I think the comfort goes back to the way they might have been taught math. You know, it was more rote and operation based and not conceptual and strategy-based. So we are asking a lot of teachers to teach math in a way that they don't trust for themselves. (S. Dorst, interview, 6/9/99)

By and large, the constructed nature of mathematical knowledge was not part of these practicing teachers' mathematical upbringing. Since the *Investigations* curriculum is founded on this epistemological base, it can—and often does—lead to conflict.

Interestingly, this same conflict did not appear in teachers' discussions about literacy. Many of the teachers interviewed considered themselves "readers" and/or "writers" and were proud of the prominence that reading and writing played in their daily lives. Although one teacher noted that they were also being asked to teach literacy in a way that is different from how they learned it, she quickly added that somehow it seemed comfortable. Thus, once again, we find a greater *perceived* need for assistance in mathematics vs. literacy.

Teachers' informal experiences with mathematics and literacy

Teachers expressed complete comfort with their proficiency in reading and writing as part of daily life and they reported using these experiences as a touchstone for their

instructional practice. However, beyond simple arithmetic, mathematics was unlikely to be a daily part of most teachers' lives. As a result, teachers found it difficult to make links between their instruction and their views of themselves as mathematics practitioners. As expressed by one principal:

> They [the teachers] are readers themselves and when I appeal to them, reader-to-reader, and then think about the classrooms and what kids need to learn, it makes sense to them. In math, a lot of teachers, if you say to them, "When you go to Bloomingdales and you see a sweater you want, do you take out a pen and paper and say, 'Let's see, I've go $80 in my purse and this sweater is $73. Do I have enough with the tax?' Do you do that? Or do you estimate in your head?" And they will say, well, "Yeah, I estimate in my head." Yet, they are still teaching kids that you do it by setting up an algorithm (S. Dorst, interview, 6/9/99).

This suggests that teachers feel more resonance to literacy than to mathematics. They personally identify themselves as readers or writers and can build upon that sense of identity and ownership in their practice. In comparison, teachers' sense of self as a knower and doer of mathematics was un- or under-developed.

Each of the above facets of knowledge appear to be more fully developed in literacy than in mathematics for District #2 teachers. On the one hand, this is not surprising given the long history of the district's literacy initiative. On the other hand, there were also intimations that, even in literacy, there may be limitations in some teachers' substantive knowledge and that their orientations toward literacy may be unexamined.

District's Professional Development in Mathematics and Literacy

In District #2, professional development in mathematics and literacy shares many features. Both literacy and mathematics professional development are multi-faceted, meaning that teachers learn in a variety of venues, with a variety of individuals, and in a variety of ways. For example, professional development occurs in district- and school-based workshops, during intervisitations to other schools, during grade-level meetings within one's own school, and in individual classrooms through the assistance of a school-based professional developer, sometimes referred to as a coach. Another similarity involves

the recognition of expertise and its value in the professional development process. In both mathematics and literacy, certain teachers are recognized as "master teachers" and other teachers are encouraged to visit them in order to see the instructional program well-enacted. Similarly, professional developers or lead teachers spend time in schools and classrooms lending their expertise close to the actual delivery of instruction. Still another similarity is the importance placed on the school as a learning community.

Despite these similarities, the unique aspects of what it means to know and do mathematics and literacy show up in differences between the two professional development efforts as well. These differences concern what is actually covered *inside* the professional development. In this section we discuss these differences with respect to the same themes by which classroom differences were outlined: specification of the to-be-learned content and styles of reasoning.

Specification of the content to-be-learned

In mathematics, the *Investigations* curriculum serves as the overarching framework for district-wide professional development. District #2 offers a variety of professional development opportunities in mathematics, ranging from introductory summer courses on mathematics and mathematics pedagogy, to focused workshops on topics such as assessment in mathematics, to study groups on particular ideas in mathematics. Some of these opportunities, such as the introductory summer course, are provided centrally by the district. Others, such as study groups and content-focused coaching (Staub, West & Miller; Staub, 1999), are site-based professional development tailored to the needs of individual schools and teachers. During the school year, many of the professional development sessions are organized around the units of the investigations curriculum. The goal of such sessions is to provide teachers with guidance regarding the mathematics in the unit, how to teach individual lessons within the unit, and the kind of student responses they might

expect during particular lessons. These sessions are organized by grade level and timed to coincide with the month during which most teachers would be teaching that particular unit.[6]

In contrast, district-wide literacy professional development tends to be organized in terms of the components of the district's Balanced Literacy Program. Teachers who are new to the district receive an overview of Balanced Literacy which focuses on the program's theory of how children learn to read and write. Later they, and others, attend workshops that provide in-depth treatment of one of the Balanced Literacy components, for example, Guided Reading. Other topics for district-wide professional development tend to center around student assessment, for example, how to do running records and use the results to inform instruction. In literacy, there also tends to be a fair number of school-based workshops that focus on aspects of literacy instruction that individual principals feel are appropriate for the teachers in their schools. Typical topics are specific pedagogical strategies and techniques, such as interactive writing, book clubs, and author studies.

The above differences in the content of professional development across these two subject matter initiatives parallels the differences in mathematics and literacy as school subjects and the differences in teachers' perceived learning needs in each subject. Mathematics professional development can be more topic focused because (a) teachers' knowledge needs in this area are unquestioned; and (b) the knowledge-to-be-learned is more delineated, organized, and sequenced. Indeed, the delineated topics of the mathematics curriculum can be used as a scaffold for teacher learning. As, suggested by the following quote, teachers frequently learn mathematics content alongside their students:

> *Investigations* is "the why." As a teacher, that's what helped me. I never learned "the why" as a student and I have learned so much about math from teaching math. It's amazing, I mean, I was never good at math. I always struggled in math and I always had tutors in math as I was growing up. I have learned with the kids so many things that I never knew because of *Investigation*s. (A. Samson, interview, 6-23-99)

[6] There is a suggested district-wide sequence for the order in which units should be taught within each grade level.

Given the large and diffuse knowledge base that undergirds literacy, it is more difficult to organize professional development around content topics. Unlike in mathematics, teachers do not cover literacy topics in a common, paced sequence. In fact, as noted earlier, the Balanced Literacy program does not specify specific books to read; particular topics in phonetics, grammar, or word structures to cover; or a set of literary genres or themes for all children to learn. Because these remain unspecified—and because teachers rarely admit limitations in their knowledge of them—professional development has tended to focus instead on the learning-to-read process and a medley of text interpretation skills such as author studies and how to make text-to-text and text-to-self connections.

Styles of reasoning

In mathematics professional development sessions, leaders often begin by asking the teachers to work on a mathematical task. Sometimes the task is the same task they will be asking their students to do; sometimes it is a "more adult" version of the student-level task. In either case, it is a complex, multifaceted task that demands sustained reasoning and thinking. The reason for doing this is not only to assist teachers in building their substantive knowledge of mathematics, but also to give them the experience of participating in a community of mathematical learners, a community that builds and verifies mathematical knowledge according to established methods. To the extent that the leader takes the opportunity to reflect on that experience with teachers, especially with regards to the implications that it has for teachers as leaders of discourse in their own classrooms, teachers can begin to better understand their role as socializers of student reasoning. Growing into that role requires explicit attention to the "meta" rules for conducting mathematics discussions, first as a learner, then as a teacher. Teachers learn to ask themselves: What messages am I giving to students regarding their role as mathematical sense-makers? How are acceptable moves during a mathematics discussion modeled for

students? How are classroom norms established for how one talks and listens in mathematics?

Teachers sometimes take on the role of learner in literacy professional development sessions as well. For example, teachers might participate as "learners" in a Read Aloud or they may take the role of discussants in a "book talk." Just as in mathematics, this could provide teachers with the opportunity to participate in a community of learners and, by doing so, to learn the "meta" rules for discussion. What are acceptable moves in a discussion framed as "reader response?" If the goal is to compare books written by the same author, do different rules apply? What about a discussion that is focused on a nonfiction book? Although we did not observe attention to these meta discussion rules during our observations of professional development, explicit attention to them would provide teachers with the opportunities to think about differences in the reasoning processes and rules of evidence for different kinds of discussions as well as the differences in reasoning between literacy and mathematics.

Professional development sessions in District #2 that focus on classroom discourse are usually guided by "Accountable Talk", a framework that the district has adopted from the University of Pittsburgh's Institute for Learning. In Accountable Talk students are taught to abide by three arbiters of "accountability:" the learning community, knowledge, and standards of reasoning. To this point, the district has focused most intently on accountability to the learning community (e.g., listening respectfully and building on others' ideas).

As such, their meta rules for discussion have not distilled any differences between literacy and mathematics. As their efforts mature, district leaders and professional developers may want to begin to differentiate between the criteria for accountability in mathematics (proof and mathematical evidence) vs. literacy (the interpretive process in literature; disciplinary ways of knowing in science, history, etc). Moreover, given that the full range of the district's literary practices do not neatly fit within a single orientation to

literature, (e.g., author studies suggest one style of literary interpretation while reader response suggests a different style), we contend that district teachers are poised to differentiate between different kinds of accountability for different orientations toward text interpretation. And, to the extent that teachers' literacy practices include discussions of nonfiction books in other disciplines (e.g., history, science), they are also ready to become aware of differences between disciplinary vs. literature-based "ways of knowing."

In summary, District #2 teachers have been shown to differ in their confidence levels in mathematics vs. literacy. Most teachers appear willing to admit to limitations in their mathematical knowledge and to discomfort with constructivist styles of teaching and learning mathematics. The picture in literacy is a bit more complicated. Despite teachers' professed confidence, there is the uneasy sense that perhaps teachers know less than they think they know. Indeed, because the knowledge base undergirding school literacy is so large and diffuse, it may be more difficult for teachers to know that they do not know all that there is to know.

With respect to professional development, we have found a distinct difference in the organizing frames for mathematics vs. literacy. While mathematics professional development is scaffolded by the *Investigations* curriculum, professional development in literacy is organized by forms and techniques associated with the Balanced Literacy program. In both subjects, however, we did find that teachers sometimes adopt the role of learner (of the subject matter) and hence have the opportunity to experience being participants in a community of learners. When explicit attention is drawn to discourse in literacy and mathematics, however, similarities—rather than differences—between the two subjects is stressed.

HOW THE SUBJECTS MATTER IN SCHOOL- AND DISTRICT-WIDE REFORM

Subject-matter knowledge is as important to the work of school and district administrators as it is to that of teachers. Administrators must establish reform priorities

and defend them to their boards and the public. Are our needs more pressing in literacy or in mathematics? Based on what evidence? Once reform priorities are established, they must layout a roadmap of how to achieve reform goals. Do we adopt a curriculum wholesale or design our own? Do we begin with all grades simultaneously or introduce reform slowly beginning in the earliest grades? Once the roadmap is sketched, they must build the capacities of their staffs to enact the reforms through well-designed systems of professional development. And finally, as the reforms mature, administrators must stand ready to make informed, fair, and useful evaluations about the progress being made by individual principals, teachers, and students.

These are minimal responsibilities of administrators who claim to serve as instructional leaders for their districts or schools. Each is discussed below with respect to how District #2 administrators guided their reform initiatives in literacy and mathematics.

Establishing reform priorities

In District #2, student assessment data has helped principals and district leaders prioritize and evaluate their reform initiatives, but it is their observations of classroom teaching and learning in each that has defined the details of their programmatic decisions.

At the end of Alvarado's first year as superintendent (1987-88), there was a higher percentage of students achieving at or above grade level in mathematics (66.4%) than in literacy (56.1%). (See Figure 1.) From these test scores, district administrators perceived the need in literacy to be greater than in mathematics. As stated by one principal, "People thought they were doing a better job in math than reading," (N. Michaels, interview, 6-10-99). This perceived need combined with strong knowledge about literacy instruction among key district administrators (Superintendent Alvarado, Deputy Superintendent Fink, and Director of Professional Development Johnstone) led easily to their decision to focus their initial reform efforts in literacy. The Literacy Initiative developed to meet this need gave rise to District #2's Balanced Literacy program, as well as a comprehensive set of support

systems for students, teachers and principals in literacy (Stein, D'Amico & Israel, 1999; Stein, D'Amico & Johnstone, 1999; Stein, Harwell & D'Amico, 1999; Elmore & Burney, 1996).

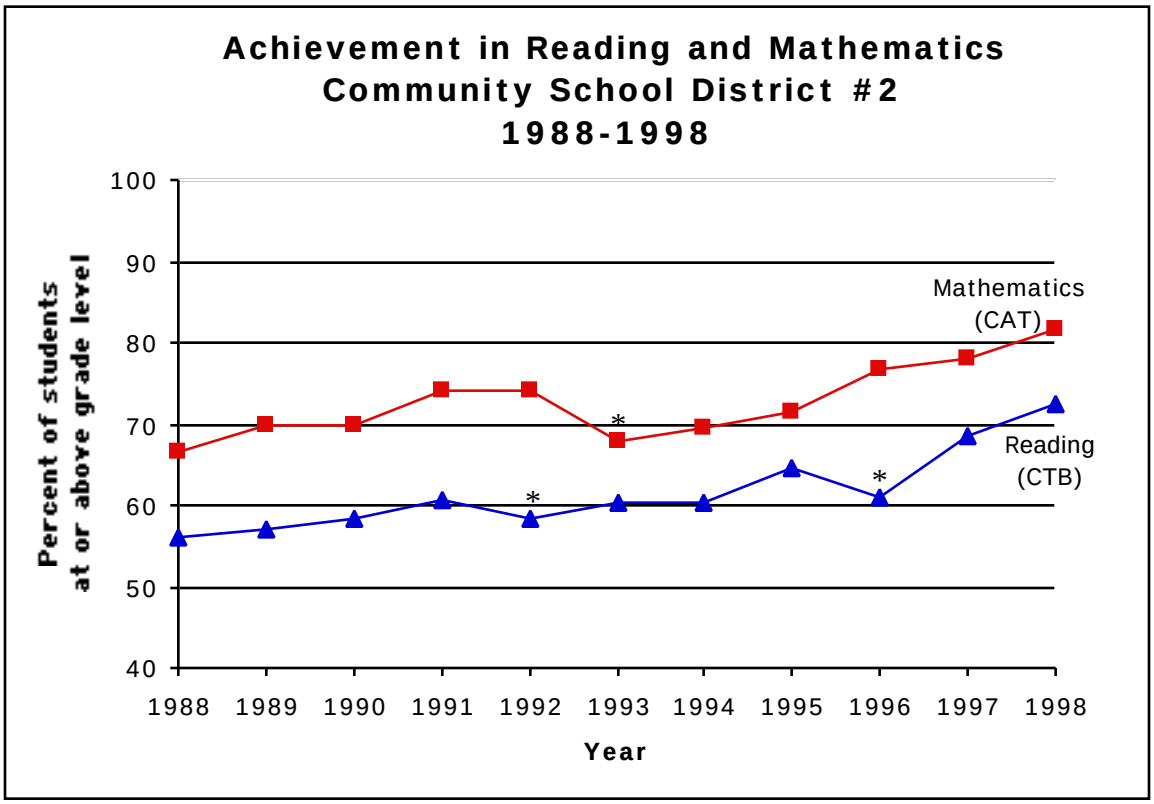

Figure 1: Reading and mathematics achievement in District #2 between 1988 and 1998 as measured by the Comprehensive Test for Basic Skills (CTB) and the California Achievement Test (CAT). (*) Indicates a test renorming.

Using achievement scores as a metric, the Literacy Initiative was considered successful. Between 1988 and 1998 the percent of students achieving at or above grade level on the Comprehensive Test of Basic Skills or CTB in Reading (McGraw-Hill, 1991) rose from 56.1% to 72.5%. However, improvements in mathematics achievement kept pace with those in literacy. The percent of students achieving at or above grade-level on the California Achievement Test or CAT in Mathematics (Macmillan/McGraw-Hill, 1994) rose from 66.4% in 1988 to 81.7% in 1998, on average a 10%-11% difference from achievement levels in literacy each year. (See Figure 1.) One might easily ask, "With such relatively strong achievement in mathematics, why implement a Mathematics Initiative at

all?" Indeed, the question *was* asked, particularly in schools where literacy scores were not as high as that of the district on average. As the principal of one District #2 school explained:

> When I came here, the reading scores were low and the teachers knew it, but the math scores weren't. They felt comfortable that they were kind of on the right track with mathematics. But they all understood that they weren't where they needed to be in terms of reading scores. . . . They knew the reading needed to do better. They didn't think the math had to. You see. So there wasn't that other compelling reason. (S. Dorst, interview, 6/9/99)

The reason that a Mathematics Initiative was undertaken illustrates an important feature of District #2 leadership: their insistence on multiple measures of success, including the quality of teacher practice and the depth of student learning in the classroom. Information on both of these is gathered through frequent administrator observations of classroom practice. District #2 leaders regularly visit classrooms in district schools as part of a supervisory WalkThrough (Fink and Resnick, 1999). During a key component of the WalkThrough, the principal takes the superintendent and deputy superintendent on a visit of the classrooms in the school to observe teaching and learning. Afterwards, they discuss the instruction and student performance in each classroom with the principal. These conversations include reflections on the strengths and weaknesses of various teachers' classroom practices and recommendations for the professional development experiences which would best support the work of individual teachers or the school faculty as a whole. Every school is visited at least once during the year and some are visited several times.

The intensive time spent in classrooms by the superintendent and her deputies gives them a substantial amount of first-hand information about classroom instruction and student learning. As a result, district leaders are able to look beyond the test scores. They note, for instance, that there are a few schools that consistently score well on standardized tests in reading (CTB)[7], despite what the consider to be inadequate literacy instruction and shallow

[7] Each of the tests taken by District #2 students have different levels of political or social importance to the district's educators. New York State uses its testing system to identify and hold accountable low performing schools, which are designated as "Schools Under Registration Review" (SURR). While SURR designation can have significant consequences, District #2 schools typically perform well on the State tests. In contrast, the CTB and CAT are the currency of conversation around school performance in New York City. Local

student work. In these cases, district leaders base their actions and recommendations for the school more on their observations than on the tests scores. At times, they must face the resistance of principals, teachers, or parents who see no reason to change the modus operandi as long as test scores are solid.

District #2's current superintendent, Elaine Fink, and her two deputies are able to evaluate and make substantive recommendations about the literacy instruction they observe in classrooms because they possess significant expertise and depth of knowledge with respect to literacy instruction and learning.[8] They do not have equally deep knowledge of mathematics, mathematics instruction and mathematics learning. Until very recently, the classroom observations and follow-up discussions associated with the supervisory WalkThrough focused largely on literacy instruction. Indeed, they were usually conducted in the morning, when most classrooms are concentrating on literacy.

This does not mean that district leaders do not observe mathematics at all, simply that literacy takes precedence. As one district administrator explained:

> In the WalkThroughs our focus is predominantly on the literacy. Of course, we do see where mathematics is happening in the classrooms, we do make sure that the materials and the manipulatives are there and we do notice when students are writing their thoughts down on paper or how they problem solve. But its not the first thing we'll comment to the head of school about, you know, it's the literacy most definitely (B. Johnstone, interview, July 1, 1998).

Despite their focus on literacy instruction, district leaders knew enough about instruction in general to be concerned about the quality of the instruction that they were seeing in mathematics classrooms. Based on student engagement levels and the rote-nature of the written work, district leaders believed that mathematics instruction in many District #2 classrooms was rather shallow despite the relatively strong CAT scores. So, in 1995-96 they hired Lucy West to start a Mathematics Initiative.

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newspaper use them as their basis for reporting student achievement and comparing school performance across the 32 Community School District. As a result, the CTB and CAT scores loom more largely in the minds of most District #2 educators.

[8] Their expertise includes both academic training in literacy and experiences as professional developers in the area of literacy.

The wisdom of beginning a focus on mathematics was validated in 1996-97 when the district began taking the New Standards Reference Exams (NSRE). While fourth grade students' basic skills in mathematics were fairly strong, their conceptual understanding in mathematics and their problem solving capacities were relatively weak. Overall, the performance of fourth graders on the NSRE in English Language Arts was actually stronger than in mathematics, a striking contrast to the historical relationship between literacy and mathematics achievement as seen through the CAT and CTB. (See Table 1 & Figure 1.) While performance on the NSRE did not change District #2's priorities (literacy still takes precedence over mathematics in most schools and classrooms), it did provide further evidence of the need for instructional improvement in mathematics.

English Language Arts	**1997**	**1998**	**Mathematics**	**1997**	**1998**
Basic Reading	57%	77%	Mathematical Skills	46%	62%
Reading Analysis and Interpretation	44%	57%	Mathematical Concepts	31%	41%
Writing Conventions	46%	45%	Problem Solving	21%	28%
Writing Effectiveness	46%	49%			

Table 1: Percent of students in District #2 achieving or exceeding standards on the 4th grade New Standards Reference Exams in English Language Arts and Mathematics

In the current climate, accountability—often based on students' scores on a single test—frequently drives districts' priorities. While it may be difficult to ignore state policies that attach consequences to poor performance on standardized tests, administrators must not fall into the trap of relying on single measures to assess the strengths and/or weaknesses of their instructional programs. District #2's leaders' refusal to rely on single measures has its roots in a decade-long history of establishing and using practiced-based standards[9] in literacy. These practice-based standards, in turn, draw on the leaders' deep knowledge of how students become literate and the kinds of pedagogical supports required

[9] Practice-based standards are used to refer to standards of practice in the classroom (i.e., classroom-based teaching and learning standards). They can be contrasted with student performance standards used to refer to standards regarding what students should know and be able to do.

to assist students' learning in this area. As their Mathematics Initiative matures, they will need to establish such traditions of practice-based standards in mathematics as well.

Using an appropriate scaffold to guide reform

Just as the Literacy Initiative shapes itself around the Balanced Literacy program, so does the Mathematics Initiative shape itself around TERC's *Investigations* curriculum. Previous work in District #2 has shown that the Balanced Literacy program not only provides a scaffold for teacher learning (Stein, D'Amico & Johnstone, 1999), it also serves as a reference point which enables observations, conversations and negotiations around literacy practice between teachers and administrators (Stein, D'Amico & Israel, 1999). *Investigations* has the potential to provide a similar set of supports for district-wide reform, but its history of adoption and adaptation differs from that of Balanced Literacy. These unique histories are due to differences in both the nature of literacy and mathematics and District #2 educators' knowledge of and comfort with each subject.

As described earlier, the content of literacy instruction (i.e.,*what* is to be learned) is more diffuse and less clearly delineated than that of mathematics instruction. The Balanced Literacy program does not attempt to define that content. Instead, it provides a set of teaching forms, pedagogical techniques, and basic heuristics for choosing the level of instructional content based on the assessed needs of individual students. Balanced Literacy can afford to be a less well-specified program, in part, because District #2 principals and district leaders can provide the extra support teachers need (Stein, D'Amico & Israel, 1999). Many of the principals were hired for their expertise in literacy, some from the district's extensive cadre of literacy staff developers. They work closely with their teachers to improve literacy instruction. They facilitate teaching meetings and study groups on topics in literacy. They observe and discuss classroom instruction in literacy. They even occasionally conduct literacy lessons in teachers' classrooms to demonstrate particular

instructional techniques. In this way, they are able to support and negotiate the shape of quality literacy instruction with their teachers.

In contrast, District #2 needed a fairly well-specified instructional core to guide their Mathematics Initiative. First, the smaller and more clearly defined knowledge base in mathematics leads to a greater need among teachers to coordinate instructional topics between grade levels. Second, the insecurity many teachers feel about their mathematical knowledge means they both want and need clear guidelines on what is to be learned. Finally, the lack of expertise in mathematics among many of the principals means they need a clearly defined instructional core against which to observe and teacher performance. Without substantive knowledge of mathematics, principals cannot supply the extra support and guidance teachers would need with a less-specified program. In other words, a set of instructional forms and techniques analogous to those of the Balanced Literacy program would not provide a sufficient scaffold for district-wide reform in mathematics.

Differences in the levels of expertise in mathematics and literacy in the district influenced not only the shape of the instructional core in each initiative, but also the evolution of each initiative. The Balanced Literacy program feels "locally produced." In fact, it is still in the process of continuous refinement by district experts. Although, its initial form drew heavily upon models of literacy instruction from Australia and New Zealand, the Balanced Literacy program also includes strategies and ideas from other nationally known projects and from adaptations suggested by District #2 practitioners. In contrast, the *Investigations* curriculum has been adopted essentially whole cloth. West and her cohort of teacher leaders and staff developers have identified areas in which they think the curriculum is weak and are pulling from the work of other mathematics researchers and instructional developers to enhance it. Thus far these changes have taken on the feel of tinkering or optimizing the curriculum.

As one teacher explained, "The math initiative seems to have its own life and it started as a program in itself. Whereas the literacy I feel like I've been getting from lots of

different experts," (T. Dennison, interview, 6-10-99). While there may be pockets of subject matter expertise in mathematics which can be brought to bear on improving the TERC curriculum, the district as a whole does not have the capacity to "grow" a program from multiple sources as it did in literacy.

Teachers have been urged to implement the mathematics curriculum as written for the first year. West reasoned that only by teaching it as a whole cloth for an entire year can a teacher begin to understand and appreciate the mathematical continuity, the conceptual depth, and the stance toward knowledge production embedded in the curriculum. However, as district practitioners become more expert with the curriculum, they will be encouraged to begin a process of adaptation, adjusting the curriculum to suit the needs of their children and to include the variety of knowledge and skills that local education decision makers deem important. Over time, one could imagine, the mathematics curriculum taking on a more local feel as well.

Building capacity through professional development

Although research has identified the characteristics of effective professional development (e.g., tailored to teachers' needs, continuous, relevant to classroom practice, content-based [Stein, Smith, & Silver, 1999; Kennedy, 1998]), we know much less about effective ways in which a district or school can organize the delivery and follow-up accountability associated with that professional development (Elmore & Burney, 1998). The professional development system that District #2 has created around their literacy initiative suggests what some of the features of good organizational management of professional development look like. One of the keys is the pivotal role played by school principals.

The principals who were hired during Alvarado's tenure already knew literacy well or had the interest and capability of learning it by attending professional development alongside their teachers. They were expected to play a key role in overseeing a process of

continuous instructional improvement in literacy in their buildings. In addition to making sure that each teacher was knowledgeable and skillful, principals were expected to focus on the ways in which professional development could be carried out to be maximally beneficial to the school as a whole. This involved articulating a vision for literacy excellence for the entire school; arranging regularly scheduled opportunities for teachers to meet and work together; and communicating clear expectations to parents, teachers, and students.

The principals in District #2 have performed these roles admirably for the literacy initiative. They hired teachers who had an affinity for literacy and who desired professional development in this area. They made their expectations surrounding literacy clear and observed teachers frequently to ascertain the degree to which those expectations were being met. They were good evaluators of the quality of instructional practice in literacy and would arrange for teacher assistance when needed and facilitate moving teachers out of positions when warranted. Although most principals had at least one literacy professional developer assigned to their building, the principal was intimately involved in decisions surrounding who received assistance and what kind of assistance. Without question, the principal was at the helm with respect to the shape and quality of literacy instruction in her building.

It is not clear if principals will be able to play this same role in mathematics. Time, resources, and expertise are clearly issues. If principals do not play the same pivotal role with respect to mathematics, the kind of role they will play needs to be explicated. In what ways, if any, should their hiring practices be changed? How will they articulate a vision of mathematical excellence for their building and ascertain if it is being met? How will or should they relate to the mathematics professional developer? How can they communicate their expectations to parents, teachers, and students? This is new territory for District #2 principals.

Evaluating progress toward reform

Differences in the level of subject matter expertise also influence the supervisory roles of district leaders. Similar to building-level leadership, district-level supervision in mathematics is not as strong and pervasive as it is in literacy. In literacy, district-level supervision occurs primarily through the WalkThrough (described earlier) conducted by the superintendent and one or both of her deputies.

West is not a deputy superintendent and does not serve supervisory functions. As a result, the deep knowledge of mathematics, mathematics instruction and mathematics learning currently resides outside the direct supervisory line. Early in the Mathematics Initiative, this separation made mathematics supervision complicated. When asked in the summer of 1998 how supervision was conducted in mathematics, the then Director of Professional Development (now deputy superintendent), Johnstone replied, "That's a good question. I don't know if you can say they're supervised in mathematics except when they're failing" (July 1, 1998). Although West did visit classrooms in District #2 schools in 1997-98, it was only at the request of the principal and was not considered a "supervisory" activity, since she is not part of the supervisory line. The Mathematics Initiative was still in its early stages and participation was at that time largely voluntary on the part of teachers and schools.

This is a distinct departure from District #2's model of improvement in literacy, which stressed the interaction of support and accountability. District leaders have credited much of their success in literacy to the manner in which supervisors both support teachers *and* hold them accountable for improved practice. Both support and accountability, however, rest on deep subject matter knowledge, something which most District #2 principals do not have.

However, as the Mathematics Initiative gains momentum, the District leadership is beginning to focus more on mathematics issues and West's role is changing. In 1998-99 all teachers in grades K-5 were *required* to at least try one or two units from the *Investigations*

curriculum. Principals noted in interviews conducted in June 1999, that superintendent Fink had begun to mention mathematics instruction more during her WalkThroughs and that more time was being given to mathematics during the Principals' Conferences. By the fall of 1999 West had established a cohort of teacher leaders supported by a small cadre of staff developers to spread the mathematics model of content-focused coaching beyond the few teachers she could work with on her own. This staff has freed her to work more directly on issues of district-wide reform in mathematics.

For example, in the spring of 1999, Fink asked West to join her during some of the end-of-year meetings she held with principals to provide more detailed feedback to them on the mathematics instruction in their schools. Fink backed West's recommendations to principals and has encouraged them to seek West's advice on mathematics matters. As of the 1999-2000 school year, West has begun to visit schools and classrooms with one of the deputy superintendents, thus providing more coordination between her staff and the supervision provided by district leadership. In these ways, the district leadership is beginning to build-up their supervision activities in mathematics to meet the standards they hold for supervision in literacy.

In summary, we have shown how knowledge of subject matter influences important administrator functions such as setting priorities for reform, making decisions regarding how to scaffold reform initiatives, building capacity through professional development, and evaluating the progress of reform. In our conclusion, we outline the kind of subject matter knowledge that administrators would ideally possess in order to successfully guide and sustain reform in mathematics and literacy.

Conclusion

Over a decade ago, Shulman (1986) noted that the study of teachers' cognitive understanding of subject matter and the relationship between such understanding and teachers' instructional practice was a missing paradigm in research on teaching. He noted

that, although the public held the common-sense idea that teachers' competence in the subjects they teach was important, little effort had been put forth to unravel the kind of subject matter knowledge that was optimal for teachers to possess. This pronouncement led to a remarkable run of research on teacher subject matter knowledge and the creation of a new construct in research on teaching: pedagogical content knowledge. Defined as the kind of knowledge that is the special province of teachers, pedagogical content knowledge is the transformation of subject matter knowledge for the purpose of *teaching.* As such, it includes knowledge of the forms of representation that are particularly powerful for teaching certain concepts, knowledge of typical misconceptions that students develop in certain content areas, and an understanding of the pros and cons of certain examples to teach particular ideas. This research has led to more in-depth understandings of the competencies that are needed to teach well and to the design of professional development that is content-specific rather than generic.

In this paper, we propose that the study of administrators' cognitive understanding of subject matter and the relationship between such understanding and the leadership administrators provide for school improvement is a missing paradigm in research on educational administration. In this paper, we have laid out why and how the subjects matter in classrooms and in professional development and have begun to identify the implications these differences have for administrators who lead building- and district-wide reform. We now take our argument a step further by suggesting that the kind of knowledge that district and school leaders need to guide reform be termed "leadership content knowledge."

Leadership content knowledge would be seen as the special province of principals, superintendents, and other administrators who see their role as primarily one of instructional leadership. It would involve the transformation of subject matter knowledge for the purposes of providing intellectual leadership for instructional reform. In mathematics and literacy, it would include practice-based standards for instruction in each content area, the forms of teacher observation and instructional artifacts that would be

needed to fairly evaluate teachers of literacy and mathematics, understanding of the kinds of difficulties that teachers are apt to experience as they attempt to change their instruction in ways called for by the new reforms in mathematics and literacy, and knowledge of the kinds of professional development that are needed to transform teachers from lecturers to reform teachers of mathematics and literacy.

In our judgment, the need for leadership content knowledge is especially acute right now. The kinds of reforms that are currently envisioned emphasize active student thinking in a way never before demanded. Classrooms are challenged to become communities of practice governed roughly by the same norms of argument and evidence as govern discourse in the disciplines (Thompson & Zeuli, 1999). Unlike never before, the teacher is charged with socializing students into particular ways of thinking, into specific methods of interacting with others around ideas, and into modes of reasoning that allow them to interpret, judge, critique, and even create new knowledge that will be recognized and accepted by their peers and others.

Teachers are experiencing difficulty with this transition (Darling-Hammond & Sykes, 1999). As shown by innumerable studies, it is possible to "get it right" on the surface, but miss the point completely at a deeper level (e.g., Cohen, 1990). If administrators see themselves as teachers of teachers they need to (a) become aware of what the new reforms are asking teachers to know and be able to do; and (b) develop understandings of why teachers are experiencing so much difficulty and what might assist them in their learning. Just as students do not learn to think by searching for key words that will tell them when to add or subtract in an arithmetic word problem, so, too, teachers do not learn to teach students how to think by learning techniques like how to ask more higher order questions. And so, administrators, too, must learn new ways of supporting and evaluating instruction, instead of continuing to rely on counting the number of higher order questions asked during an observed lesson.

In our judgment, principals are and will experience difficulty with this transition. Just as with teaching, it is possible to "get it right" on the surface, but miss the point completely at a deeper level. Because reform pedagogies can look so similar on the surface (students "constructing" their own knowledge, use of more "hands-on" activity, more group work, etc.), it is easy for administrators to be lured into thinking that "good instruction is good instruction" regardless of the content area. With this mindset, administrators will surely miss the nuanced differences between mathematics and literacy that are the subject of this paper.

Two areas of administrator practice stand out as ripe for the development of specific understandings of what leadership content knowledge might entail: the observation and evaluation of teaching practice and the management of professional development. In District #2, administrators were able to rely upon their observations of literacy practice in the classroom to judge how well their literacy initiative was progressing. In that content area, leaders felt comfortable evaluating if the forms suggested by the Balanced Literacy program were being followed, with special attention to the extent to which individual student needs were being met. In this paper, we've argued that the ill-specified nature of the content of literacy instruction makes it difficult to focus on the actual ideas being transmitted in a more systematic way, but wonder if more definition here might be useful (see below). We also wonder whether more specialized scrutiny could perhaps be given to the underlying models of discourse guiding various discussions of text, with an eye toward the extent to which teachers were able to differentiate forms of reasoning and thinking in ways appropriate to the goals of the lesson and topic under discussion.

In mathematics, it is not clear what administrators focus (or should focus) on during their observations and how they differentiate various levels and kinds of teacher competence. Is being able to judge mathematics lessons at a course grain level—a level that allows one to spot a real problem—sufficient? Or should they be able to make finer differentiations. How can the gradual building up of more and more sophisticated forms of

reasoning within the classroom be witnessed? Perhaps observing one lesson is not sufficient to judge how instruction is going. Mathematical ideas frequently develop over days of extended work and the real fruits may not be evident during a single lesson. Are perhaps other venues of teacher performance (how he or she interacts in a grade level meeting; the results of an extended project) needed to judge teacher performance?

With respect to managing professional development, what kind of subject matter knowledge would administrators need? First and foremost, they would need to understand the level of knowledge and understanding that their teachers have and how that measures up against what they need to teach in these new and demanding ways. This is a tall order to fill without putting oneself in the position of a learner of the subject matter. Just as teachers cannot establish and lead a community of learners in their classrooms if they themselves have not participated in a community of learners, it will be difficult for administrators to grasp what kinds of knowledge and experiences are essential for their teachers if they themselves have not experienced what it means to know and think in mathematical or literate ways. Obviously, administrators cannot become expert knowers and doers in all subject matters. However, if they experience learning and understanding in one subject area deeply, they will begin to feel the dimensions of being deeply steeped into a particular way of knowing and communicating. This provides some grounding for thinking about what it means to participate in other communities of knowledge.

The construct of leadership content knowledge that we are proposing in this paper will inevitably raise the issue of limitations imposed by time, resources and expertise in most school systems. Critics will ask: Is it feasible for administrators—especially those in high schools—to be knowledgeable in all the content areas? Let us be clear: We are not proposing that educational administrators know the subjects in the same was as do teachers and/or professional developers. Rather we are proposing that they need to understand the subjects in ways that directly intersect with their functions as school and district leaders.

Further investigations into the nature of this kind of subject matter knowledge will be needed to flesh out this concept.

There is a subgroup of principals in District #2—those for whom literacy practice is firmly under control—who have begun to actively struggle with their role as leaders in multiple subject areas. One of these principals is quite self-consciously constructing a definition of her role as an instructional leader in mathematics. She visits mathematics classrooms on a regular basis with the building's mathematics professional developer and debriefs afterwards. Based on these experiences, as well as her attendance at professional development workshops with her teachers, this principal is beginning to develop a keen awareness of the key similarities and differences between mathematics and literacy. This has already led to quite different observational routines in the two subject areas, as well as different ideas about school-wide grouping and student assignment practices. Given the limits of time and resources, this principal readily acknowledges that she will never know mathematics as well as she knows literacy. But she expects that her deep knowledge of literacy will help her to realize what she does *not* know in mathematics and be wise enough to seek out (or build in) mathematical expertise. Reflective principals like this can help researchers build high—yet reachable—definitions of leadership content knowledge.

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