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The Role of Curriculum in Teacher Development

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There are several views of curriculum that we, as mathematics educators, often encounter. (In this essay, "we" refers to the group at TERC that has been working through these ideas while developing the K-5 curriculum, Investigations in Number, Data, and Space.) One is that teachers, especially elementary teachers, are so under-prepared in mathematics that the curriculum must do everything for them. It must tell them exactly what to do, when to do it, and in what order. Once this was called "teacher-proof" curriculum. Now, of course, that term is no longer fashionable, so teacher-proof-ness, when it is espoused at all, is couched in other terms. For example, a textbook representative recently described to me the lessons in their teacher's guide by saying, "And it's all scripted for the teacher, so that they know what questions to ask." This view of curriculum assumes that there is a Right Way to organize and teach the curriculum, and that, if we have a curriculum that embodies this right way, students will learn mathematics well.

Another view holds that it is only the teacher who knows her students' learning needs well enough to continually modify the classroom environment in response to those needs. Therefore, the teacher must develop her/his own curriculum. Sometimes this view admits that, because teachers are not yet adequately prepared to teach mathematics, we may need innovative curricula now -- temporarily -- until we have accomplished the job of large-scale teacher development. This is the view of curriculum as a necessary evil -- we don't want it, but we can't yet do without it.

A third view, somewhere between these two, is that of curriculum as reference material. The argument goes something like this. Teachers don't have the time or energy to develop all the curricula for all the subjects they teach. Therefore, they need good reference materials from which they can put together a curriculum of their own. This allows teachers to be creative and to become acquainted with new ideas. The curriculum is a reference library in which teachers browse.

We disagree with all of these positions. Or, perhaps, since all of these have probably been somewhat unjustly characterized, it is more accurate to say that we are trying to find some new ways to articulate what curriculum contributes to the learning and teaching of mathematics. This new articulation is possible, and necessary, because new curricula that are currently being developed are quite different from our traditional notion of what a curriculum is and make possible a different kind of partnership between teacher and curriculum materials.

Perhaps we have been without "good" curricula for so long that we have very low expectations about what curriculum materials can provide. We are used to thinking of a curriculum as something that robs the teacher of her professional judgment and/or does not model mathematical thinking and reasoning as promoted in the NCTM Standards. We would like to put forth a new view of what curriculum can be. We believe that curriculum materials, when developed through careful, extended work with diverse students and teachers, when based on sound mathematics and on what we know about how people learn mathematics, are a tool that allows the teacher to do her best work with students. As these new curricula begin to appear, we need new ways to think about the role of curriculum.

We see the best mathematics teaching environment as a partnership between teacher and curriculum. Both teacher and curriculum bring important contributions to this partnership that the other cannot do well. It is not possible for most teachers to write a complete, coherent, mathematically-sound curriculum. It is not insulting to teachers as professionals to admit this. Curriculum development, like teaching mathematics, is a job that requires people and resources; it requires a skilled team of mathematics educators spending many thousands of hours writing, thinking, working in classrooms, and listening to students and teachers. We do not sell teachers short by recognizing that they cannot do this job.

But only the teacher is there in the classroom, observing and trying to understand her students' mathematical thinking. Individual teachers must continually assess and modify their mathematics program for their own classroom. Thus, curriculum is not a recipe or a compendium of what "should" be taught at a particular grade level. Rather, it provides both a coherent mathematics program for students, based on the best thinking available in the field, and material that supports teachers in making better, more thoughtful, more informed decisions about their students' mathematics learning.

The link between curriculum and teacher decision-making is a focus on mathematical reasoning. Neither curriculum nor teacher can fully anticipate the complex and idiosyncratic nature of the mathematical thinking that might go on among thirty students in a single classroom during any one mathematics class. However, both teacher and curriculum contribute to a repertoire of knowledge about student thinking that leads to better mathematics teaching and learning.

How does this work? Each curriculum unit presents a few, related significant mathematical ideas. The curriculum provides four types of information about these ideas: a series of activities for students, explication of aspects of the mathematics content, discussion of students' mathematical thinking in the context of this particular content, and pointers toward issues of pedagogy that arise as students engage with the content. Only the first of these is something provided directly for students; much of what the curriculum provides is for teachers. Curriculum is, in fact, primarily a tool for teacher development. This is a radically different conception of curriculum; it is one that makes it possible for teachers to truly be in partnership with the curriculum rather than simply using it as a guide for sequencing student work.

In order for this partnership to work, curriculum must do its job. What it provides for students is important, but what it provides to support teachers is equally important. Curriculum can only support teachers honestly if it has been developed through intense partnerships with teachers and students. In this kind of development work, curriculum authors are in classrooms frequently, each part of the curriculum is thoroughly field-tested in diverse classrooms, and field data are carefully reviewed to inform revision of the materials. This kind of development process results not only in good investigations for the range of students, but also in a wealth of information about how students approach those investigations, what mathematical issues are central to their understanding, what pragmatic and pedagogical issues arise for the teacher, and ways in which teachers can modify and/or extend the investigations to suit their individual class. The curriculum materials must then be designed so that this information is available to the teacher. Let me give an example from a recent episode in a field test classroom of how this works. (Teachers quoted in this essay are participants in an NSF-funded project, Teaching to the Big Ideas, a joint project of EDC, TERC, and Summermath for Teachers at Mt. Holyoke College. Pseudonyms are used.)

Meg, a second-grade field test teacher, is using an activity called "Enough for the Class," in which students consider whether the number of cubes in a bag is enough for each student in the class to have one. If it's not, how many more are needed? If it is, are there extras? Meg thinks of this problem as a subtraction situation and assumes that her students will do something like the following sequence of steps: 1) find out how many cubes are in the bag; 2) remove the number of cubes equal to the number of students in the class; 3) figure out or count how many cubes remain. One day she gives them the following problem: there are 16 blue cubes and 17 red cubes; are there enough for the class? Students quickly decide that there are enough for the class of 26 students and begin figuring out how many extra cubes there will be. Meg is taken by surprise when some of her students solve the problem this way: I can take 10 cubes from the 16 and 10 cubes from the 17, that makes 20. Then I need 6 more cubes, so I take away 6 from the 16. Now I have 26, enough for the class. That leaves just the 7 cubes from the 17, so there are 7 extra. Without ever finding the total, Meg's students have solved the problem. Meg wrote about this episode: "Many children actually did solve the problem the way I expected. Many didn't. . . They showed a lovely ability and willingness to take numbers apart and put numbers together. They . . . had made sense of what was being asked. But they still didn't figure out how many cubes there were in all! I am not sure what surprises me more -- that so many children don't think explicitly about the whole or the total when solving these problems, or that it never occurred to me that they didn't have to."

This is exactly the kind of episode that finds its way into the curriculum itself. We may include a classroom dialogue, based on this episode, to provide teachers with illustrations of the kinds of issues that tend to come up as students talk about their approaches to a mathematical problem. In addition, we would include notes for the teacher about the mathematical issues raised in this episode, in this case, the relationship between addition and subtraction in the structure of this problem and how students' strategies are related to their understanding of the number system. Episodes like this one provide guidance and examples for teachers who may

encounter similar mathematical issues in their classrooms. They alert teachers to important mathematical ideas they may have been unaware of, and they provide guidance about engaging students with these ideas. In many ways, each mathematics unit of study, then, becomes a minicourse for teachers about a particular domain of mathematics. As teachers use new curriculum units more than once, they can learn more mathematics and more about their students' mathematical thinking. What they learn from watching and listening to their students will illuminate what they read in the teacher book, while what they read there will alert them to how to better listen and watch. Curriculum must help the teacher assess her students' understanding throughout the year, provide models of mathematical talk that stimulates and supports student thinking, and offer ways for the teacher to learn more about the mathematics she is teaching.

We have often observed that -- as part of the old view of curriculum as the RIGHT WAY -- when something in a curriculum doesn't work, people consider the curriculum -- or the students -- to be flawed. Rather, the curriculum itself must assume that what it suggests won't always work. No matter how well curriculum materials are tested, no matter how many times they are revised, each school brings its own mix of resources and barriers, each classroom brings its own set of needs, styles, experiences, and interests on the part of both teacher and students, and each day in the classroom brings its own set of issues, catastrophes, and opportunities. We could test and revise endlessly; each classroom test would result in new ideas we might incorporate and raise new questions about pedagogy or content. But at some point we have to decide that the curriculum materials themselves are good enough -- ready for teachers to use and revise in their own classrooms. Teacher decision-making, therefore, is key, and the curriculum must be designed with this assumption in mind. The teacher's role is to connect the particulars of her classroom and students to the investigations presented by the curriculum.

Taking this role seriously involves making decisions about which mathematical ideas to pursue. Because there are so many connections within the domain of mathematics, issues often emerge from students' thinking that are different from what the teacher -- or the curriculum -- anticipated. The teacher must decide which mathematical ideas are important to pursue at this time with the whole class, which might be best to pursue with an individual student, and which to put aside. In the following episode, a fifth grade teacher is faced with a choice about whether to move away from the topic on which she expected to focus in order to deal with an unexpected issue that comes to her attention.

Kate watched her students play a number game which involved arranging digits to form 2-digit numbers with a sum as close to 100 as possible. (The game is described in Mokros & Russell, 1995, p. 22.) This game was challenging for many of Kate's poorly prepared students. The game was part of a series of activities focused on developing knowledge about 100, its place in the number system, and its relationships to other numbers. Students scored each round by comparing their sum to 100: a sum lower than 100 was scored as a negative number (e.g., 97 would result in a score of -3); a sum higher than 100 resulted in a positive score (e.g., 101 would result in a score of 1); and a sum of exactly 100 resulted in a score of 0. At the end of several rounds, students added their scores from all rounds; the closer their sum to 0, the better their

score. Kate noticed that when students used a number line to compute their total score, they tended to skip zero. She wrote, "The score of 0, which usually meant nothing, was now the highest score . . . they decided that if 0 was actually the winning score, it was a pretty important number and really shouldn't be skipped. Usually when they had a score of 0 (for example on a spelling test), it wasn't great. So they had to rethink what 0 meant in this game while they played." As she watched her students, she realized that they were confused about the relationship among positive integers, zero, and negative integers. She devised a problem about owing money to support her students' explorations of these relationships. After some work on these problems, she asked her students to consider what +1 cent, 0 cents, and -1 cent might mean. They decided that +1 meant "a penny you could hold," that 0 meant no money and you don't owe anything, while -1 cents was "a cent that you owe." She concludes, "I'm not sure they understand this, and I hope to work on it some more . . . but it did raise a lot of issues." She lists questions she'd like to explore with her students: What is 0? How is 0 used in different ways? Are there numbers that are less than 0? How many numbers can there be that are less than 0?

Curriculum Materials as a Tool for Teacher Development

Decisions like Kate's are complex. Kate needs to consider what mathematics is important for her students, whether a digression from the ideas they are currently pursuing is warranted, and how to create a context and problems that are appropriate for her students. How can teachers like Kate be supported as they use good curriculum materials, try to understand student thinking, and design next steps? It is clear to all of us who have been involved in developing curriculum that any curriculum materials, no matter how well they can be used, can also be used badly and can be misunderstood and distorted. Teachers have not necessarily been prepared, in their own mathematics education, to focus on student thinking or to see their role as partners with the curriculum in the way that we have described this partnership here. The best use of good curriculum materials is in the context of a long-term staff development program which engages teachers in ongoing reflection about students' mathematical thinking and continued work on mathematics content with their peers.

Professional development courses that use innovative curriculum materials as a core can be designed for both preserve and inservice teachers. For inservice work, this professional development/implementation might be composed of two elements: intensive components (e.g., a two-week summer course, or several three-day sessions during the school year) and ongoing, long-term interaction (e.g., a study group of grades 3-4 teachers within a school) that provides a continuing forum for thinking about mathematics content and about students' mathematical thinking. The ongoing school-based component provides the scheduled occasions and communication with peers to stimulate continued thinking and learning as well as help in grappling with the everyday, pragmatic concerns of implementation. However, it is critical that the design of these experiences does not focus on "how to do" the curriculum, but on the development of the teacher's professional expertise -- increased experience with mathematics content and with understanding the development of mathematical understanding. This means that teacher leaders who act as facilitators for these ongoing groups need their own support and training so that they can help the teachers in their school or system focus on understanding

children's mathematical thinking and developing approaches to best support and extend that thinking. The use of curriculum materials as a core for professional development provides a direct link between teacher enhancement and what actually happens in the classroom. Professional development of this sort has two advantages: (a) the teachers leave the professional development experience with a concrete unit (or units) of instruction -- a way to begin implementing what they have learned, and (b) the materials themselves continue to provide information and support to teachers as they teach. They serve as a catalyst for engaging teachers in thinking about children's mathematical thinking -- a way of continuing the professional development experience.

Another valuable tool to support this kind of staff development would be classroom episodes, written by teachers, about their own experiences as they used particular curriculum materials. These episodes would describe students' mathematical work, discuss issues about mathematics or children's mathematical thinking that were raised for the teacher by this work, and give examples of decisions made by the teacher based on her observations and reflections. Schifter (this volume) describes some ways that this can happen.

Elsewhere (Russell, Schifter, Bastable, Yaffee, Lester, & Cohen, 1994), we have posited that we can never prepare elementary teachers well enough before they enter the classroom: "In fact, it appears that the new mathematical understandings teachers must develop and the teaching situations they must negotiate are too varied, complex, and context-dependent to be anticipated in one or even several courses. Thus, teachers must become learners in their own classrooms." Teachers must continue to learn mathematics and to learn about students' mathematical thinking as they teach. Curriculum materials that are designed to support ongoing teacher development can be an important tool in this endeavor. As teachers teach a particular curriculum unit -- or related units at different grade levels -- they meet together regularly. Material for teachers in the curriculum becomes a focus for study and helps the teachers identify areas of mathematics about which they need to know more and questions about children's thinking they need to investigate. These efforts need to be supported by a good facilitator, which may be a teacher who has received special training, as well as writing by other teachers about mathematical issues they have faced in their own classrooms.

Meg and Kate are doing exactly what we want curriculum to orient teachers towards -- reflecting on students' thinking, trying to understand it, and then planning the next step. This constant decision-making should be what we expect. It's not a matter of using curriculum or not using curriculum, but of intelligent teachers using intelligent curriculum intelligently.

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Reference

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