MATHSCAPE: SEEING AND THINKING MATHEMATICALLY

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A middle school curriculum for grades 6–8, developed by the Seeing and Thinking Mathematically project.

MathScape is a comprehensive, three-year middle school mathematics curriculum that focuses on mathematics in the human experience. Throughout the 21 units of this curriculum, students experience mathematics as fundamental to human endeavors throughout the world and through history—endeavors such as planning, predicting, designing, creating, exploring, explaining, coordinating, comparing, and deciding.

The curriculum focuses on four mathematical strands that develop across the three grade levels: number; algebra; geometry and measurement; and statistics and probability. *MathScape* supports students in learning mathematics by having them do mathematics, use and connect mathematical ideas, and actively construct their own understandings.

There are seven *MathScape* units at each grade level. Each unit provides five to six weeks of material and explores several mathematical topics in depth, such as "what is a function?" or "how do you interpret information on Cartesian graphs?" The mathematics is presented in contexts designed to appeal to middle school students, such as music, sports, and architecture, as well as in purely mathematical contexts. The curriculum engages students in hands-on investigations that involve mathematical concepts, skills, and processes, and provides opportunities for practice and application of basic skills. Lessons prompt students to work collaboratively with their classmates, communicate about mathematics in class discussions and writing, and reflect on their thinking and learning.

Each unit of the program features an assessment package with options that allow teachers to choose when and how to assess students. Resources include embedded assessment tasks with detailed rubrics and sample student work; skill quizzes; final projects; pre-assessment tasks; and suggestions for using portfolios.

MathScape teacher materials support teachers in using the materials flexibly to meet the needs of their students. The *Teacher's Guides* include detailed lesson plans; reproductions of the student pages; sample student work; homework options; reproducibles; and From the Classroom comments and tips from teachers who have taught the materials. Each guide also provides Math Background pages where teachers can find information about the mathematics of the unit.

Calculators are used throughout the curriculum. Each unit identifies Technology Options, appropriate junctures for the use of spreadsheets and other optional computer software programs. Suggestions for using graphing calculators are provided throughout the eighth-grade units.

Each of the *MathScape* units consists of a *Teacher's Guide* and a non-consumable student book. The student books are also available as a hardcover consolidated text (one per grade). The units are supplemented by an optional student reference book with definitions, examples, and practice problems for basic skills, called *Hot Words, Hot Topics* (one student book and one teacher's book per grade level). Most of the units involve the use of manipulatives.

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GLENN KLEIMAN AND SUSAN JANSSEN ▸ DEVELOPERS

Glenn Kleiman, Ph.D., is Vice President and Senior Research Scientist at Education Development Center, Inc. (EDC) and is on the faculty of the Technology in Education Program at the Harvard University Graduate School of Education. With a background in cognitive and developmental psychology (Ph.D. Stanford, 1977), he has been involved in technology in education since the "days of 8K PET computers" as a software designer, curriculum developer, author, instructor, workshop leader, and consultant. At EDC, Glenn has directed several large-scale projects funded by the National Science Foundation, the most recent of which produced the *MathScape: Seeing and Thinking Mathematically* middle-school curriculum.

Glenn's writings about technology in education span from an early book in the field, *Brave New Schools: How Computers Can Change Education* to a recent article in the *Harvard Education Letter*, "Myths and Realities about Technology in K–12 Schools." He now directs the EDC Center for Online Professional Education and the EdTech Leaders Online™ program. He is also a principal investigator in the Northeast and the Islands Regional Technology Education Consortium, funded by the U.S. Department of Education.

Glenn Kleiman

The design of *MathScape*

From the beginning, we wanted students to think of mathematics as a central human endeavor relevant to all parts of life, all people, and all time. We wanted students to understand mathematics both as something that has been developed over thousands and thousands of years, and as something that they can use and connect to their own experiences. We thought about mathematics, like language, as a central part of being human, influencing how humans think about and view the world. We were influenced by some of the ethnomathematics[1] work—we believe that doing mathematics is a way of viewing the world. Underlying those views are processes, mathematical ways of thinking that include conjecturing, representing, making models, testing hypotheses, generalizing, systematizing. We call these processes "seeing and thinking mathematically," and they are an essential part of the curriculum.

In designing the curriculum, we looked at the central mathematical ideas—the big ideas in mathematics for the middle grades, such as proportional reasoning. We looked also at content strands—number, algebra, geometry, statistics—and then at specific content objectives. For instance, students need to know what an average is, and what a linear equation is. Each one of those included smaller, related objectives.

MathScape has an interdisciplinary bent and tries to connect mathematics to other subject areas. For example, our *Gulliver's World* unit connects to literature, the *Designing Spaces* unit connects to architecture and social studies, and the *Mathematics of Motion* unit connects to science. We made sure that the primary focus in those units was on the mathematics, but we pushed to include substantial interdisciplinary connections.

In terms of teaching and learning, the *MathScape* materials certainly represent our view that kids need to actively engage in building their own understandings of mathematics, and that there are many different approaches to building those understandings. In designing the program, we looked for ways of building on kids' own strengths, and for ways to create materials that would work for different audiences in the schools. We wanted the materials to support pedagogical approaches that we thought were beneficial—like cooperative learning—and to do this in a balanced way. The program has collaborative activities, but it's not all collaborative. We work with physical models when it's appropriate; we use technology when it's appropriate. We tried to blend approaches in a comfortable, usable way.

In the materials, we really tried to provide ways of helping teachers address a multicultural audience, largely by having what we call "culturally open" activities. A lot of the more traditional programs use pictures to represent all kinds of kids in their textbooks. That's fine—kids should see their own world represented in the pictures. But for *MathScape*, we thought it was much more important to have activities into which each child could bring his or her own experience or background.

[1] Ethnomathematics explores how mathematical ideas are embedded in social and cultural activity.

For example, we have a number activity where we look at the number words of different languages and analyze patterns, and kids bring other languages into the classroom. In another unit, we work on games of chance, and kids can bring in games with a chance element that are played in the cultures their families are from. So sharing experiences is a very important part of the curriculum.

From the beginning, we were also committed to creating something that could actually be used, rather than a program with a bunch of wonderful ideas that would end up sitting on the shelves. So we did a lot of testing in classrooms. And in the materials, we really tried to deal with the tension between helping people change and do new things while recognizing that what they do fits into a given context at school.

Mathematics

In developing the curriculum, it was a real struggle to figure out what to include from all the good mathematics and good activities we could have included. We spent the early part of the project making lists of all the things that are important in middle-school mathematics, including various state standards and the NCTM *Standards*. There was so much that we wanted to incorporate that I remember finally saying to the rest of the staff, "Okay, tell me some things that should *not* be in middle-school mathematics." No one had anything to say. It's very easy to build too much into a curriculum; there are very real pressures that have led to the phenomenon of U.S. curricula being a mile wide and an inch deep. Adoption processes require you to meet certain objectives; state standards and national standards have other requirements. So the challenge for us was to really push back on those pressures, and to provide via the curriculum the time we knew kids needed to delve deeply into certain topics and really develop their mathematical understanding. I think we did reasonably well on that objective, although de-emphasizing some material is always a tough choice to make.

MathScape does a lot more with algebra than has traditionally been done in the middle-school curriculum. The algebra strand builds on the work that Charles Lovitt has done in Australia—he was also one of the developers of the curriculum. The mathematical modeling approach of *MathScape* gives us a very natural way of developing algebraic thinking. Early in the program, we build algebraic ideas through a patterns approach, helping students recognize patterns and understand multiple ways of representing them. Then we move into representing patterns as algebraic equations, and students solve problems about those patterns by solving algebraic equations. We then have students do some nice work on algebraic models in a unit called *What Comes Next?*, which uses the context of population growth and growth in other areas to look at linear and nonlinear models. We worked very hard to represent algebra as something that has meaning and understanding—it's not just a set of magical formulas that you plug things into, hoping that you have the right one.

Skill development

In the materials, we tried to convey a balanced approach to computation and skill development. We do think it's important that kids be able to do computation without a calculator or computer, but speed is not our primary concern. The drill and practice in traditional curricula is all about rapid computation. There's really not a whole lot of reason to develop that skill—nobody has to do much of that anymore. But there are lots of reasons why you need to be able to compute and estimate. In developing the curriculum, we struggled with whether to teach just one

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approach or one algorithm, or whether to develop multiple algorithms. We didn't really believe that we could expect kids to magically develop their own algorithms, but we did want them to develop some understanding of algorithms, rather than just memorizing a series of steps.

In *MathScape*, to help develop those understandings, we often give kids a series of problems and then reverse the form of the problem. If they have A, B, and C, they're asked first to figure out C from A and B. Then we suddenly reverse the problem, giving them B and C, and ask them to figure out A. So they have to develop their thinking about the process itself: "How did I do that, and how can I switch it around so it works?" We try to give them some insight into the solving processes that way.

Instructional approach

We have had a lot of feedback from *MathScape* teachers who say that kids who had previously thought of themselves—and have been thought of by their parents and teachers—as poor in mathematics suddenly are doing very interesting things and becoming leaders in class. I think that is a result of giving kids different ways of approaching the mathematics. Some students learn best from tying mathematics to literature, as in our *Gulliver's World* unit. The story context in *Gulliver's World* gives kids a different angle on mathematics; it engages them and moves them away from thinking "I don't know how to multiply." Instead, in the Gulliver context, we say, "Things are 12 times as big in Brobdingnag. Take an object and make a scale model that's Brobdingnag in size," and those students figure out a way to make it 12 times bigger. That approach is powerful for many students. For other students, taking a very visual approach to mathematics has been successful; kids who might have trouble with computation sometimes have incredibly strong visual skills. For others, physical modeling is more effective. There are alternative entry points offered throughout the curriculum that have enabled many more kids to have successful experiences in middle-school mathematics.

In each unit, we begin with the students' intuitions and their own language, and with phenomena that students can physically and visually explore. Students begin to extract patterns and relationships from their own hands-on work and out of their own experiences, and then move to more formalization of the mathematics. Also, in each unit, we manage to build in a creative aspect. For example, in our *Chance Encounters* unit, which introduces a lot of probability, kids create their own game. In the geometry unit, *Designing Spaces*, students actually design structures in the process of learning to represent three-dimensional structures two-dimensionally.

One nice piece of feedback we've gotten from teachers is that when using our curriculum, they feel like they really get to know their students. One teacher told me she always felt jealous of the English teachers in her school, because when kids write essays they reflect so much of themselves—and this teacher felt that, comparatively as a math teacher, she really never got to know her students. But because *MathScape* has more open-ended, creative activities, she feels she now has a better sense of who her students are and how they approach learning.

Assessment

One big issue with implementation is figuring out how *MathScape* intersects with a particular district's assessment. An assessment that includes a lot of what we do in the curriculum, that balances number with the other strands of the curriculum

and includes more open-ended problems, is going to be a better assessment of students' learning with *MathScape*. A more traditional assessment that focuses very heavily on computation won't give students credit for all the other mathematical understandings they have developed in this curriculum.

Technology in *MathScape*

We certainly assume that calculators are available to students, and we have provided lots of opportunities in the *MathScape* materials to use them. There are also activities that use graphing calculators, but they are optional.

Frankly, in our original plans for the curriculum, we anticipated a lot more use of computer technology. We struggled with that; there were lots of things we could have done, but we also felt committed to making sure the materials were really usable. Many teachers, if they aren't already using technology, see technology as an additional burden rather than as a tool to help them meet their curriculum goals. We do have one unit, *Getting Down to Business*, in which kids develop an understanding of spreadsheets, and you really do need some access to a spreadsheet program to make the unit work well. We developed some software to accompany other units, but made that software optional. In all of our units, we give guidance on ways you could support the content of that unit with particular pieces of software. Overall, we've tried to support those teachers who want to use computer technology, but we have not required it.

Teacher training and support

We've seen *MathScape* used very successfully in school districts across the country where the teachers are getting good training and support. In situations where there's at least some support and preparation for teachers, the curriculum can be used in a variety of ways—as a full curriculum or as stand-alone units in combination with other materials. At the same time, it's unreasonable to think that *MathScape* will miraculously make good math teaching happen. We see *MathScape* as one piece of the puzzle, not something that can carry the full weight of changing mathematics teaching and learning. I'd say the same about any curriculum, no matter how well it was written.

Ideally, *MathScape* would be used in a context in which it supports an overall agenda of improving mathematics teaching and learning. There would be support for teachers—training, coaching, mentoring—and various other elements in place. *MathScape* can be used quite well in that situation, providing lots of opportunity for in-class discussions with students, collaborative work, and exploratory work. But the curriculum can't change mathematics teaching and learning by itself.

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Susan Janssen

Susan Janssen is currently the project director of the MathScape Curriculum Center, a center that supports districts in the implementation of the NSF-funded middle-school mathematics curriculum *MathScape: Seeing and Thinking Mathematically*. Prior to directing the center, she was one of the main developers of the *MathScape* curriculum, and has worked extensively with middle-school and high-school mathematics. She holds an undergraduate degree in mathematics, and a Masters in Secondary Education. Professionally, she is especially interested in alternatives to the traditional classroom, and learning more about how and for whom these alternatives work best.

Changes in teachers' practice

For most teachers, as they begin using *MathScape*, they're thinking primarily about classroom management—"How do I make this thing work?" As teachers get further into teaching the curriculum, they often become more adventuresome in trying different kinds of pedagogical strategies. For example, teachers who didn't really do discussions in math class before will start trying to pose questions to kids. At first, they start with questions for which they have a pretty good idea of how kids will answer. Little by little, they move toward questions that really are open-ended—that are genuinely soliciting student thinking and using that to inform their teaching. That's a gradual change for many teachers, because it involves giving up some control and predictability, which can be difficult and requires practice.

Another change I see is in assessment. Teachers often start out using a lot of familiar skill quizzes and approaches along with the curriculum. Then they take on one new approach, and experiment with that—they may decide to use the final project for the unit, or to do one of the open-ended assessment lessons. Again, little by little, teachers experiment with the different kinds of assessment strategies within the units and begin really looking at what kinds of information they get in return. When they see what they can learn about their students' thinking, they think "Maybe I do want to incorporate more different ways of assessing my kids."

Teachers are sometimes surprised at both the depth and sophistication of what kids do in a *MathScape* unit, and, as a result, change their expectations of what kids will and will not be able to do. A few special education teachers we interviewed recently talked about seeing their kids do some amazing thinking once they were outside the realm of drill and practice. These teachers were really impressed with what students were coming up with, and began to wonder if they were setting their expectations lower than what students could really do. So now they've started to adjust their expectations. That happens for teachers with regular education students, too.

Professional development for teachers

In order to teach these materials effectively, of course you need to know what's in each lesson. But you also need to know what's behind each lesson, so that when students give responses, you, the teacher, are in a position to recognize, "Ah-ha! There's a strong mathematical connection being made, even if this student doesn't see it. I can help bring it out."

In training, we always have teachers do some mathematics themselves. We ask them to do the activities first as learners and not to think immediately about how they would teach this lesson. We want them to see how they themselves think about the math. Then, when they're working on problems in a group with other teachers, they begin to see that other people think about the mathematics in different ways. Teachers see how you can have success by coming at this material through different approaches, and this experience prepares them for the variety of ways students are going to approach activities in the classroom.

It's important for teachers to do activities with some mathematics content that may be new to them. For instance, in statistics and probability units, teachers' familiarity with the content may be rusty. It's also very important to do activities in

which the approach to the content is really different, even though the content itself may be familiar. For example, our *Language of Numbers* unit develops an understanding of place value, but in a way that's not at all traditional. Students build a mystery device out of beads and pipe-cleaners, and use it to create a way to represent numbers. They think about what the position of the beads has to do with how much the number is. It's the same content—place value—done in a way teachers probably haven't seen before.

Once we've worked on content, invariably the question comes up, "Okay, I'm starting to understand what this is all about, but how do I teach it?" One of the big misconceptions we see about pedagogy is that the units are an application you do after you've taught the content. Sometimes teachers try to pre-teach all the skills you need for a unit, so that students can then use the unit to practice those skills—rather than letting the skills and the content develop through the doing of the unit. So, in training we offer models of what other people have done in their classrooms and share roadblocks people have run into. We also give teachers time to reflect on their concerns about using the materials.

Support for teachers

In addition to training on the curriculum, it is very helpful if schools can build in a series of meetings to provide ongoing support for teachers, bringing everybody together to reflect on how things are going and to get help and advice from each other. Some schools do this once a month or once a quarter. Other schools set up a system where everybody has a peer partner to talk to about the curriculum. We find that it makes for a very successful beginning if teachers have opportunities to talk to each other about what they're doing.

For the program to be implemented successfully, it is almost critical to have somebody within each school who is a real advocate for the curriculum—who either has more familiarity with it than other teachers do, or who is just very enthusiastic about making it work. In schools where that support is absent, when teachers run into challenges, there's nobody right there to help them. It's easy for those teachers to get discouraged. In schools that do have someone right there, teachers feel they can go down the hall after class and say, "Help me rethink how to do such and such." They're having a lot more success—that seems to be a key piece of support.

Implementation

We recently began working with an urban district that I think has a close-to-ideal implementation plan. Prior to adopting *MathScape*, they did a lot of work thinking about their mathematics goals and developing a framework for what they wanted to achieve. Then they chose *MathScape* because it met those goals. That work has really given them a good foundation.

As developers, we trained a group of the district's lead teachers on the curriculum. Now those lead teachers provide training for other classroom teachers and serve as ongoing resource people. The lead teachers are very experienced with *MathScape*—they had taught a number of the units prior to the district—wide implementation. The district has a lot of other support structures in place. The district's K–12 math coordinator keeps a close eye on the flow between elementary, middle, and high school, so it's a very coordinated effort. A lot of thought has been put into the big picture of mathematics education.

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Now, not every school district has the money and the staff to implement this way. But we do encourage districts to be careful and thoughtful in developing a plan for implementation. We encourage people, before they dive into implementation, to chat with other experienced districts, or to call us for suggestions and tips.

Parents

In the school districts we've worked with, we've heard two completely opposing stories about parent involvement and how to think about it. When people ask me about building support with parents, I always like to tell both stories, because they both describe approaches that have worked well in very different situations.

The first story is much more common. Many districts, when they take on a new curriculum, really try to let the parent body know what's happening. They have a series of workshops for parents, a family math night, and other kinds of programs where parents can find out what's going on. They are very up-front with parents and explain what this effort to use a new program is going to be like. Parents have a chance to try some of the activities, and they hear the rationale for the change.

One school district we worked with took a different approach, and introduced the program very quietly and gradually, one teacher at a time. This was a district that was considered very academically strong—over 90% of their students graduate and go on to college. The work with *MathScape* began when two 8th-grade teachers decided they wanted to try the units. They knew that saying the words "change" or "reform" in their district would light all kinds of fires and make people nervous. So they decided to try one unit in their classrooms to see how it went.

That first unit went really well, so they tried it again the next year. Students were engaged enough by the unit that they began talking about it in other classes. Other teachers started asking, "What are you doing in class? Students are talking about what's going on." Teachers' curiosity got piqued, and eventually one or two others said, "Well, I'll try one of these, too." So it spread slowly. Meanwhile, the original two teachers now were doing three units instead of just one.

Parents started hearing kids talk about math differently, and asked teachers, "What are you doing in your class?" Those teachers shared with parents what they were doing—especially because they had already engaged the kids and had some successes to show. Teachers felt strongly that this was the right way to go—to establish some success first, and then talk to parents.

There were certainly some downfalls to this approach—there were parents who really were not pleased about the program, and who put up some real obstacles. One parent was also a school board member and decided to fight against the program. When that happened, a number of other parents spoke up in favor of it. The teachers felt very supported by those parents. So it was certainly not a smooth road, but it was a grassroots way of introducing and building support for the curriculum. ■

BARBARA SCOTTO ▸ TEACHER, GRADE 6

Why *MathScape*?

Driscoll is a school that takes its mission very seriously. We look critically at various areas of the curriculum and the way we teach them. We've really changed our practices in a lot of ways, working on various subject areas in depth over time. Math has been our most recent focus. We've picked a specific skill, such as whole-number operations or algebraic thinking, and looked at where the concept is taught, how it's taught, and what kinds of thinking we encourage. We've devoted a lot of faculty meetings to looking across the curriculum in this way. We have also done problem-solving as a faculty. At Driscoll we have a principal who supports this kind of inquiry, which makes it a very stimulating place.

In Brookline, we also have very forward-thinking people in charge of our math program. Both of the district math coordinators have kept abreast of developments in the math field and have wanted Brookline to be looking at the newest and the most effective methods of teaching math. We had been using DMP (*Developing Mathematical Processes*) which, when we adopted it, was already a step away from the rote drill-and-skill math we see in traditional programs. But that program had been in place for 10 years, and our thinking had moved beyond it. We were interested in having children become better math thinkers.

I was on the curriculum committee, and we looked at a variety of programs. Some were very traditional, like Prentice Hall and Houghton Mifflin texts—people from those publishers came to present their programs. And then we looked at *MathScape*. We were really looking for something that aligned with the NCTM *Standards* and that moved away from the traditional computation-math piece. *MathScape*'s use of the *Standards* was a change in emphasis from what we had seen in other programs.

I don't think there was ever much doubt in our minds about which program to choose, although there was a lot of nervousness about whether traditional math skills would be covered and whether *MathScape* would be a complete program. At one point, we discussed whether each class should have a set of textbooks that teachers could use in addition to the *MathScape* materials. But then we realized that for a lot of teachers, if the textbooks were there, they would never move into the kind of teaching we hoped they would do with *MathScape*.

The important elements in *MathScape* are the same elements that you see in the NCTM *Standards*: thinking conceptually about math, thinking algebraically, writing about math, learning to do math in real ways that you would see in your life. Thinking about math as if there were problems there that you can solve, reasoning about math, and understanding the relationship of one number to another are all things that I believe are very important.

Changes for students

What we're seeing in *MathScape* is an approach to math that really fosters mathematical thinking. Kids are asked to think about ideas, work with manipulatives and think about how they work, and extend their thinking to new situations. Plus, they're doing things that are fun, instead of sitting there with a workbook doing 16 division problems in a row. They're trying things out and really using their minds. I used to hear "What are you going to teach us next? We've already had that. We

Barbara Scotto has been teaching 6th grade for eight years at Driscoll Elementary School in Brookline, Massachusetts. Except for a 10-year hiatus to have a family and earn a degree in library science, Barbara has been teaching since 1961. Five years ago, she started piloting some units of *MathScape* and then taught more units as they became available. Currently, she teaches the full program.

From grades pre-K through 8, Driscoll Elementary has about 400 students, with two classrooms at each grade. The city of Brookline has both urban and suburban schools, and Driscoll is a combination of the two, serving children from a wide range of socioeconomic, education, and ethnic backgrounds. Because Driscoll houses a Russian bilingual program, it has a large population of Russian students.

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know this. Math is so boring. I hate math." I don't hear that much anymore. The activities are interesting and fun for kids, not just something they've done year after year. I see lots of growth on the part of the kids, lots of confidence in themselves as math thinkers. A lot of kids now think of themselves as good math thinkers who, in a traditional program, might not have thought that. They really like math. They can see that math is much more than just adding and subtracting and multiplying and dividing.

The kids are working with one another in cooperative ways. I've found that kids who I never would have expected to be good math students blossom because they're working with people who are stimulating their minds. A lot of learning occurs in social situations, so having children work together to learn is a major strength of the program. For example, today we were working on part of the *Patterns* unit. Children were working in pairs, discussing patterns they could see, and then we pulled together for a whole-class discussion. One girl, a very bright math student, pointed out a very elaborate pattern. And she said, "I haven't figured out why it works yet." So everybody in the class looked at the pattern, and another girl said, "Oh, I see why it works." She went to the board and explained how this pattern worked. So not only did she understand it, but she also then had the responsibility of explaining it to the rest of the class. The children really saw this—I could tell because there were questions asked and refinements made. Now, I could have stood up there and explained it, but they probably would have tuned out. It was that interaction that made it compelling for kids.

Developing number sense

The kids who come out of these NSF programs are able to think about math conceptually in an incredible way. At the same time, one of the pitfalls we can fall into is helping them develop their conceptual ideas and not their number sense. When I think back over my teaching career, I recall the kids who could compute fantastically, but who couldn't move beyond that. I have children now using *MathScape* whose understanding of math is phenomenal. And yet some of them haven't done enough number manipulation to know the more practical aspects of math. I think having children explore a problem before you give them an answer is a good approach. But you also have to think about when you need to move them on to something else. Personally, I think at some point you need to move children on to consider the question of an efficient method. That might be the standard algorithm and it might not—you just don't want them to spend a lot of time reinventing the wheel every time they want to know what 8 x 6 is.

Mathematics

I think the program has expanded the concepts that children are learning. They're looking at data. They're looking at number systems. In *The Language of Numbers*, they're looking at the way numbers and number systems are put together in language. We do this activity with words in different languages to see how each language constructs number words. It's a real expansion of the areas that were traditionally covered in math. Literature is woven in—the whole *Gulliver's World* unit is based on *Gulliver's Travels*. Students begin to see math as part of the fabric of everything, not just this isolated subject that some people do. That's one thing that I think is wonderful about the whole *MathScape* program.

Even the various areas of math are woven in from one topic to another. Kids are using math skills, but they're not using them in isolated ways. Concepts are woven

together in a more integrated way than you see in traditional math programs. In a unit like *Designing Spaces*, you see something that most children wouldn't think of as being math. Before the unit, when you ask them what math they might use to build a house, they'll think of the measuring angles piece but the whole issue of how to design a house for a certain climate wouldn't have occurred to them as being math. They find area and perimeter, but they do so in the course of designing structures of different sorts. As they construct their houses of various shapes, students use their basic computation skills to figure out the choices they can make architecturally. The whole field of math is expanded for them. They can see math in many more things.

The algebraic thinking is extraordinarily strong in *MathScape*, and the program does a very nice job with the data topic. I really would say that understanding number systems, working with data, and the geometry piece are all well done in 6th grade, although I feel I have to supplement the geometry unit, *Designing Spaces*. The units I think are weaker are the ones having to do with fractions, decimals, and percents. There are some very good lessons there, but they don't hang together as well as they should.[1]

Supplementing

In the 6th grade materials, I find that *MathScape* makes a lot of assumptions about what kids know. I find I have to fill in a lot. That's not really *MathScape*'s problem—kids come in with certain pieces of knowledge, depending on what program they've had in elementary school. We do some computation practice as part of our morning work, starting with addition and working from there. In certain instances, I feel that *MathScape* doesn't spend enough time on an idea. For instance, the fraction units—*Number Powerhouse* and *From Zero to One and Beyond*—really don't spend much time on addition and subtraction of fractions. They make the assumption that that's been done before 6th grade. *MathScape* does cover converting mixed numbers to improper fractions and so forth, and there are certain kinds of addition and subtraction of fractions that you probably won't be able to do until you can do that step. So I do some supplementing of addition and subtraction of fractions when we begin the unit. Otherwise, I follow the curriculum pretty much in the sequence that we have laid out in Brookline, which is different from the sequence that the publisher has laid out. We use some 7th-grade units in the 6th grade.

I supplement with other things—a program called ADD[2], which contains a variety of skills, and a loose-leaf binder called *The Problem Solver*.[3] We do some problem-solving from that. I have a lot of materials and just pull as needed. I supplemented the program we used before *MathScape*, too, just because there are many wonderful math materials out there and children vary and have different needs. It's hard for one program to meet all of those needs on every topic.

Serving a variety of learners

MathScape does require a lot of ability to reason logically, which isn't easy for some kids. At the same time, I see more children being successful in math than I did when we were using a more traditional program. It is a very language-based pro-

Concepts are woven together in a more integrated way than you see in traditional math programs.

[1] The developers have proposed and are working on a revised flow to *Number Powerhouse* and *From Zero to One and Beyond*, to better link these concepts. For more information, contact the MathScape Implementation Center.

[2] *Arithmetic Developed Daily* (ADD) is published by GROW Publications in Racine, Washington.

[3] *The Problem Solver* was published by Creative Publications in the 1980s.

One thing I love about the teacher's guides is that they include excerpts of teachers talking about ways they've approached the lesson and examples of problems their children have run into.

gram, which makes it difficult for any child with limited English proficiency. But I would say that that's the way math is. Math is embedded in language—you can't separate the two. I want students to be as comfortable thinking about math concepts as they are about language, so that if I say to them, "Read this and tell me the main idea," they can do that. I want them to be comfortable in thinking about a math problem, to know what it is asking them to do and to have some sense of how to do it or how to think about it. I also want them to be able to estimate, so that in their real life when they come upon something new, they have some idea of what a reasonable answer would be. I really would like them to be math-literate.

In the *Patterns* unit we've been working on, I had the kids do a pre-assessment that really grabs their attention. Students are asked to construct houses with toothpicks and then figure out ways to predict the number of toothpicks used to build any number of houses. This gives me a good sense of my students' understanding of patterns. Some of the children who are our weaker math students were really seeing the pattern and were able to take leadership roles. You can't always predict who will be able to do a problem like that easily.

Different units are easier or harder for kids with different abilities. In *Designing Spaces*, some children struggle with the geometry because it's heavily visual. But that's generally not the same child who struggles with fractions or a more number-oriented piece. In a unit like *The Language of Numbers*, there are children who can really think about those number systems ideas, but who have a lot of trouble with fractions. So there are lots of different areas in which children can show their strengths. That is very good and very important.

Teacher materials

In the *MathScape* teacher's guides, the lessons are set up so that it's easy to see how one can follow that lesson, and there are some interesting questions to explore with the students. One thing I love about the teacher's guides is that they include excerpts of teachers talking about ways they've approached the lesson and examples of problems their children have run into. All of that teacher talk is extraordinarily helpful because it makes me start to think in different directions. "Oh, this is what somebody did. Well, I could do thus and so."

I also love seeing the examples of student work that are included in the materials because, again, it gives me a sense of the kinds of things I want to do. I wish there were more examples like that in the student books so students could see a model of what somebody else has done.

I like the fact that *MathScape* has embedded assessments right in the lessons. There are also skill quizzes. I use both to give me different kinds of information about kids. I look at the embedded assessments to see how children take what they've learned and use it. And I look at a skill quiz to find out more specific information, for example, if they're having some trouble with equivalent fractions. The quizzes are not perfect. Sometimes the directions are not as clear as I'd like them to be, and the items are too close together in the layout of the quiz, so I will often rewrite things like that. The "Dear Dr. Math" letters are nice because having children write their thinking about math really makes them clarify their thoughts. I can often tell by the way they explain their reasoning whether or not they understand an idea.

For the most part, the homework assignments included for each phase are good. But sometimes I need more. *Hot Words, Hot Topics* has extra materials I can use for

homework, but sometimes they're set up in such a way that the homework is either too easy or too hard, or it may be skill-and-drill when I want something a little different or more fun. So I end up supplementing homework assignments sometimes.

Challenges for teachers

It's not so easy for a new teacher or a teacher who doesn't have a good grasp of math concepts to plunge into this program. Traditional math programs were easier for teachers who were insecure about math or who were just starting out. That's not *MathScape*'s problem, but it is a fact of life and may be true for a lot of these new programs. First of all, *MathScape* takes a fair amount of classroom management, because you're dealing with kids at a variety of different ability levels. As the teacher, you have to keep a lot of balls in the air at one time. You're having students work cooperatively. You're having them do some pretty challenging math that may not be something you're very familiar with. That makes it difficult—but it's not something that can't be overcome.

I've taught the program now for so long that it has become second nature to me. I can pick up a lesson and know exactly how I'm going to approach it. I'm familiar enough with the material that the way the class plays out and the way we have discussions works and is easily manageable.

Pacing

It's clear in the published *MathScape* materials that they tried to structure the number of topics covered in a unit and the number of days spent on a unit for teachers who needed that guidance. That schedule doesn't always translate to the reality of my classroom. With a program like *MathScape*, children need to have time to think about and work with the problem, to talk about it a lot and explore their ideas. Sometimes a lesson that looks like it's going to take two days may take four days. What I do every day is based on what happened the day before and where the kids are. I'm not saying I don't do long-term planning, but I might decide there is more to be gotten out of a lesson and it is valuable enough that we ought to spend another day on it. If there are rich discussions going on or the explorations are fascinating, I can't worry about the fact that I'm not going to get as far as I need to. I might decide later on to cut something out. Teachers get caught up in feeling they have to get through the material. I'm not saying I'm not aware of the pressure to move forward, but I think that we sacrifice a lot by not going in-depth when the opportunity arises and the kids are fascinated by the work.

Teacher support

Brookline did a lot of in-service for teachers, which was extraordinarily helpful. We met with the developers and they walked us through each of the units. We really had a chance to do the activities that the kids were doing. That was very valuable. The other thing that I found really useful when I started teaching *MathScape*—and I still do—is working with another 6th-grade teacher. We both started this new program together. Now we spend a lot of time talking math. We really are able to support one another in very important ways. It has been very helpful to have somebody I can talk to who is in the same position that I am. Helping people find someone with whom they can talk about their math teaching is important, whether the connection is through an e-mail conference or a study group or just someone you work with.

With a program like* MathScape, *children need to have time to think about and work with the problem, to talk about it a lot and explore their ideas.

Articulation to and from the middle grades

The *Investigations* program is used in our elementary grades. Basically, *Investigations* and *MathScape* have a very good fit because the children are used to working cooperatively and they're used to coming up with different ways to solve problems. By middle school, students are used to writing about math and explaining how they figured out problems. The basic approaches of the programs are pretty much the same. We're always watching to see how the fit between the programs plays out in the Brookline schools. For example, we wonder if we need to be doing the data unit in 6th-grade *MathScape*, since that's one of the things that must be done in 4th- or 5th-grade *Investigations*. I think there's enough in the *MathScape* data unit that hasn't explicitly been taught before that we should keep it. For example, this year when we started talking about mean, median, and mode, the terms seemed pretty unfamiliar. But we often ask the question, "Are there pieces of units we can get rid of while keeping others?" As we work with *MathScape*, we are finding places where we have to make adjustments and where we don't need to repeat things because they were done in *Investigations*.

I tend to think the fit is very good with what follows at the high school, too. *MathScape* feeds very nicely into the IMP program, which is used at the high school. I don't know how well it fits with a traditional high school mathematics program. I think that kids who come out of *MathScape* can think mathematically. They have had many of the elements of Algebra I, but not all. So, a high school teacher who is getting children who have had Algebra I and children from the *MathScape* program should be aware of certain skills differences. ■

DONNA SCHULTHESS ▸ MATHEMATICS TEACHER, GRADE 7

Donna Schulthess has taught middle school for over 20 years in the Northwest Local School District, a fairly large suburban district close to Cincinnati, Ohio. With 10,000 students, the district consists of nine elementary schools, three middle schools and two high schools. The population includes many students who have recently moved into the district from the inner city. This is the third year that teachers are using *MathScape* in all three of the district's middle schools.

Selecting *MathScape*

We started an adoption about five years ago. At the time, we knew we wanted to move toward reform-based mathematics. We knew the books that we were using weren't really working, and we weren't happy with the results we were getting with our students. The change was also driven by our proficiency tests. These tests weren't just multiple-choice tests; students were being asked to write more and to explain the math in essay questions. We knew we wanted our students to know how to write and communicate well mathematically.

So we looked at the proficiency outcomes that our students needed to pass. The proficiency test is a state-required test and students need to pass it in order to graduate from high school. We have a 6th-grade proficiency test, and at the time, we were supposed to have a sophomore test. Now they're putting it back into the 9th grade, and we don't know what they're doing with it in the future. But taking those tests and looking at what the goals were on those tests, we wanted to make sure that our curriculum matched, so that we were preparing our students for the test. But, we didn't really want to teach to the test.

Our high schools are also very involved in the Schools at Work Project, which works to ensure that all students have algebra, geometry, and higher-level math before they leave high school. That's being required of our high school students now. So we needed to make sure our middle school students were being prepared to graduate from high school.

We were also not happy with the fact that our previous curriculum at 6th, 7th and 8th grades just seemed to repeat. We wanted to make sure that there was some continuity there, that the students weren't doing the same skills over and over again. By looking through books—many different authors and many different books—we narrowed it down to three programs that we thought would meet our goals. Then, taking those three—*MathScape*, *Connected Math* and *Mathematics in Context*—we piloted parts of each of them for ideas. *Math in Context* was so new at the time that we just had bits and pieces of it, so we really didn't have a strong sense of where it was going.

We also thought about the teachers within our district. What would they accept? We wanted a book that all teachers could teach from, which isn't real easy with a reform-based mathematics program because there's a lot of training required. And, we can't require all of our teachers to take training without paying them for it. Of course, our district doesn't have the funds to do that, so we wanted to make sure it was a book that we felt the teachers would be comfortable teaching from with limited instruction. So we had different teachers piloting different books. We held several meetings throughout the year with representatives from each building. In the meantime, the teachers representing those buildings would get information from teachers in the buildings: What did they feel comfortable doing? Which units did they like? Which units didn't they like?

During this process, we had a checklist of our goals and objectives for the district, and checked which books met our goals. *MathScape* was more closely matched to what we wanted than any of the other books. We also liked that with *MathScape*, we could pick and choose books to meet our district needs. For example, we use some of the 7th-grade books at the 6th-grade level and 8th-grade books at the 7th-

The students have a chance to bring their creative writing and their personalities to math class. It's fun getting to know them as people.

grade level. We were able to rearrange the books and give ourselves some flexibility. We use a trimester system here, so we can use some units in a trimester class. *MathScape* just seemed to match our goals for our math program.

Instructional approach

The basic approach of *MathScape* is to start out with an investigation or an idea, and have students build on those ideas through activities. Each book has either three or four phases in it, usually with a cumulative lesson at the end of each phase, where students are assessed on the skills that they've just worked on—the more formal evaluation. Within each phase there might be either three or four lessons. Usually, the first lesson is an activity that gets students to start thinking about an idea, and then it builds from there. I've also found that the first phase is an introduction to the rest of the book. If students can get through the first phase and get the basic concepts and ideas, then the rest of the book builds on that phase.

I think the project-based approach that *MathScape* takes just seems to make more sense to students. We don't have as many questions like: "Why do I need to know this?" or "When am I ever going to use this?" Students can see more where the math is going.

I also like the fact that *MathScape* doesn't just teach one method. The program shows you several different ways to look at something. With algebra, for example, we can look at the graph, we can look at the table, we can look at the equation. There are different ways to approach it, which makes the kids feel more comfortable because they all learn differently. You know, when the teacher is up there saying, "This is the way you have to do it—you have to do it my way," sometimes it makes the kids very reluctant to learn. Now, suddenly, there are lots of ways you can look at a problem: "Which way do you like best? Which way works for you? Can someone else explain another way to look at it?" The students respond to sharing their own methods for doing things. They really get into that.

Impact on students

I think the program is working well for students. I find that my students are more interested in class and my grades are better overall. In the past, as a teacher you gave students a page full of math problems, checked them right or wrong, and gave them back. You never really got to know the students. But when students are writing to you, you get to see their personalities. The students have a chance to bring their creative writing and their personalities to math class. It's fun getting to know them as people. I enjoy reading what they write and responding to it, and watching their enthusiasm grow. When my students answer the Dr. Math[1] questions, some of them really get into it and will write me long stories. That's exciting for the students who aren't as mathematically inclined but are a little more creative; it gives them a chance to express that part of their nature, too.

MathScape really extends my students' algebraic thinking. The approach makes even my more concrete learners willing to think a little bit more abstractly. I'm thinking of The Language of Algebra unit I'm using right now with my 7th-grade classes. My students are more willing to accept that abstract thinking because the

[1] Dr. Math questions are interspersed throughout the units. Each is presented as a letter written by a confused student, asking Dr. Math to explain something about a particular concept. Students are assigned to respond to the letter, as if they were Dr. Math.

book starts out giving them a meaning for variables, so they're more willing to work with variables after that. Normally, when you start throwing variables at students, they're very upset. They want to know what that letter means. It's hard to explain to them that it represents any number. But the way The Language of Algebra develops it, they're willing to go into equations without questioning all of the time: "Why are we doing this? What does that mean? What is x?" The book just uses variables to describe that the numbers are what changes. It makes sense to students when you start talking in those terms. Students used to get so confused and nervous when they saw variables, and they don't tend to anymore.

Because my students are learning and understanding more, they seem to retain it longer. Especially when I see the spiraling happening, I can go back and say, "Remember when we were doing such and such in this book? Well, we're going to take it a little bit further." And the students will remember those activities, instead of me saying, "Remember when we solved one-step equations?" They don't remember those kinds of things but they'll remember an activity, or they'll remember something specific, like a certain puzzle that we did.

The way the topics are approached in *MathScape*, I think the students really have an understanding of them when we finish. We're just beginning to see that students are better prepared. Our 8th graders are the first group of students who have used the program for three years. The high school teachers have told us, too, that they're much more pleased with the freshmen coming in, that students are better prepared for the high school curriculum in their freshman year. They're beginning to see a difference.

I feel that we're doing much deeper mathematics with students, especially at the 6th-grade level. Our 6th-grade teachers, most of whom are not mathematically trained, are elementary teachers who just happen to be teaching math at the 6th-grade level. They're in awe of what their students can actually do. Their concept of math was more basic skills. They are amazed at the kind of skills that the students can do, especially once they, themselves, understand what it is they're teaching, which was difficult at first.

I'm doing math with my 7th graders that sometimes even amazes me. We were using the Making Mathematical Arguments unit with exponents and, just out of the blue, one of my students said, "What happens if you have a negative exponent now?" I've never had a 7th grader ask me that before. I was in awe! We were able to look at the patterns and look at what might happen. It was very easy for students to see that when you have a negative exponent, it becomes a reciprocal. They could follow that and it made more sense when we talked about other examples. It's the first time I've had 7th graders wanting to know about negative exponents.

Implementation

During the implementation of *MathScape*, our district did one thing that was wonderful. For the first year we adopted the program, we wrote a grant to provide all of the teachers implementing that year with release time once a month. It was a half day where teachers at different grade levels could meet and discuss the books, how they were doing, what they were doing, and what was working or not working. That helped greatly. We were able to get *MathScape* trainers in to do the training, and that also helped. Our coordinator also was able to get grants from local universities to help with our training. The year before we started, we had an entire week where teachers were trained on the units that we would be teaching when

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…now there are enough teachers in the district who feel comfortable with **MathScape** *that we can help out the new people as they come in. That's the main thing — by supporting each other, none of us has felt that we were out there on our own.*

school started. Then, as I said, once a month we had a half-day release where teachers could get together. They also brought in teachers and EDC trainers for a couple more of our in-service days during that school year.

We weren't able to continue the same level of teacher support after the first year. We had a grant to cover the substitutes for one year, and then we couldn't continue it. So the kind of support we get now is from each other. We try to support the new teachers, too, as they come in. Before school begins, we have some workshops with them. We try to break them up into what they're going to be teaching, and we bring in teachers who teach those grade levels. When I did the training, for example, I brought in everything for the first book that the teachers would be teaching—all the materials that I augmented it with. I even brought in my lesson plans for the whole first phase, and gave them everything that they needed to make them feel more comfortable, because the beginning of the year is so overwhelming. Each time they're ready to start a new book, we do the same thing. As a building, we pull together; we have a few teachers who are great about sending out materials, and are not the least bit hesitant to share things. So, we'll put packets together for the teachers each time they start a new book, and send them the materials. Many of the materials are from two workshops given by the developers of *MathScape*. In each of the buildings, the department heads have folders with these materials. They make sure to copy and pass them on to the new teachers.

Two summers ago, the district paid for me to go to Raleigh, North Carolina, where I was trained more thoroughly in *MathScape*, so that I could come back and support teachers in my district. This is the first year that we're not going to have anybody coming in from the outside, because the money is starting to dry up a little bit. But the training has continued; now there are enough teachers in the district who feel comfortable with *MathScape* that we can help out the new people as they come in. That's the main thing—by supporting each other, none of us has felt that we were out there on our own.

Challenges for teachers

I do some of the teacher training for our district; we do a lot of training during the summer. Sometimes, teachers are unsure about what the students really have to master and they can get too bogged down in one specific thing. A lot of us still have the mindset that students have to master everything. We think that once you teach a concept, students are supposed to master it before you move on. Teachers have a difficult time letting go before the students have mastered ideas, even though we keep reassuring them that students will see it again, and they don't have to master this skill yet. This is especially hard for 6th-grade teachers; since they don't have the advantage of seeing the 7th and 8th grade, they're not sure about the spiral and they really don't see where it goes. Now that teachers have taught it for a few years, they're more comfortable with it because we keep telling them it's okay.

Every year we have teacher turnover. Very often, when a new teacher picks up the book, they're overwhelmed by the whole format. This is getting better. Once they get used to it, they're okay, but first we have to get them over that initial shock, explaining, "This is how we're going to do it," and helping the teachers out. The new teachers who are coming in seem to be very accepting of this approach, and very gung-ho. I don't feel they're being trained appropriately at the college level still, but that's something that will come. They're very willing to learn.

Assessment

With assessment, again, it's your mindset—you have to be very willing to accept more than just a test as an assessment. As a teacher, you have to be willing to observe more, to watch as the students are working. *MathScape* allows you to do those kinds of things. When the students are working on a project, you can observe, you can walk around. You can stop and ask questions: "Why are you doing this? What's happening here? Can you explain what that's all about?" You really know if the students understand what they're doing. Again, a lot of it I base on getting to know my students, which I find easier with this curriculum because I can get to know them much better. I can watch them when they're working with someone. I can walk around the room and listen to their conversations. I can read their writing. And I can really assess their understanding, instead of assessing just how well they memorized everything for the test.

I'm thoroughly enjoying the Chance Encounters probability unit right now. I have two lower level groups; actually, they're both inclusion classes. We have several special education students in there. Using Chance Encounters, they really understand probability. Today we were discussing the difference between theoretical and experimental probability, and they were all able to tell me the difference. We did an experiment with coins, flipping coins and finding the heads. They start out with carnival games, where the students play different games. Then we go into what's fair and what's unfair. What makes it fair? What makes it unfair? Then we get into the probability behind it. Then we do an entire class experiment with flipping coins. They color these little strips and I put them on a poster board. And the students can actually see that the probability is one half, and that when you do it experimentally, it comes very close to the theoretical probability. The more experiments you try, the closer it comes to that. They can really grasp that concept and that idea. Then they can carry it over to another situation, such as when we start talking about what happens if we toss dice.

Supplementing the curriculum

We pretty much use straight *MathScape*, but depending on the students that we have, we do supplement a little bit. Sometimes students need a little more practice with certain skills. We supplement from the Creative Publications *Pizzazz!* series, the *Middle School Math with Pizzazz!* book and *Pre-Algebra with Pizzazz!*. The *Pizzazz!* series doesn't use the same theories, but it reinforces the skills that are developed in *MathScape*.

Articulation across grades

Sixth grade teachers are saying that the students are coming in better prepared. There are certain things—for example, the data unit—that I think they just don't need because they have so much of it in the elementary school. So, we're hoping that maybe we can push a few more books down into the 6th-grade level that are 7th-grade books, and eliminate a few because the students are coming in with some of the things from *Everyday Math*. We did a K through 8 adoption and chose *Everyday Mathematics* for the elementary grades. They started the same time we started, so this is their third year also.

At high school, all of our freshmen are taking Algebra except for the students who are getting their freshman Algebra class out of the way as 8th graders and receiving high school credit for it. Those students will go into Geometry their freshman year. But all the other students will be taking Algebra their freshman year and

teachers are finding them better prepared to take Algebra. At middle school, with *MathScape*, the kids who aren't in the regular Algebra are in one of two other levels. One level is taking the first half of their Algebra as 8th graders, and they finish it up at the high school. The other level is still taking pre-Algebra, although they're using the same *MathScape* books. They just go through them more slowly, and they probably don't get to a couple of the higher level units. Then, they will take a full year of Algebra at the high school.

For curriculum at the high school level, we're using *Core-Plus* (*Contemporary Mathematics in Context*), including the middle school students who are getting high school credit. This is the first year the high schools are using *Core* completely. Last year, they were still trying to decide which way they wanted to go, whether they wanted integrated or more traditional. At first, they were going to let the kids opt into either the integrated or the traditional. But they ended up just doing totally integrated. I'm not a hundred percent certain how that's being accepted and what's happening there.

Parents

One of the challenges, at times, is working with parents. The students seem to thoroughly like the book and accept it. It's the parents who say, "This isn't the way we did math." It's a little more difficult to convince them, and I've had some parents that just downright tell me they hate the book. Students will go home and say something negative or say, "The teacher doesn't teach me how to do it," and then the parents buy right into that. So this approach takes a lot of explaining to the parents. That's probably my biggest challenge, trying to educate them about what we're trying to do. It's getting better because our parents, especially the parents of the 8th graders now, are very accepting, and they understand where we're headed. The kids are better at that too, now, because they've been in this a few years. Plus, with the use of *Everyday Mathematics* in the elementary grades, parents are beginning to understand that there are different approaches, and they're becoming more accepting. So it's getting better, much better.

Our coordinator also had parent meetings at each of the middle schools. She set aside time, she invited the parents to come in, and explained the reasoning and the theory behind the program. Teachers were there and we did a couple of activities with the parents to show them where we were headed and what was going on and to give them some background on *MathScape*. Of course, the parents who came were mostly the ones who are the most interested, and maybe not the ones who complain the loudest, but at least we got the word out. We also went to the PTA and explained the theory behind the curriculum to them, so we tried to get the word out about why we were doing what we were doing. It also helped that I've had a couple of board members' children in classes the last few years, and they were the ones who approved our adoption. So it helped that they had first-hand knowledge of what was going on. ■

EILEEN HERLIHY ▸ DISTRICT MATHEMATICS COORDINATOR

Selecting *MathScape*

Our curriculum selection process started with our K–12 Local Systemic Change grant from the National Science Foundation, *Reaching Every Teacher*. The first year of the grant, 1996–1997, we explored the teacher as a learner, and pedagogical techniques and best practices. In the second year, we looked at curriculum, and specifically considered three standards-based curricula: *MathScape*, *Math in Context*, and *Connected Math*. Teachers were unhappy with the programs they were currently using—an Addison-Wesley math program at 6th grade, and *Transition Math* at 7th and 8th grades. The 7th- and 8th-grade teachers, especially, felt that the existing program was very difficult for the students. Because our community is mixed socioeconomically, some children come to school with fewer skills than others, and are always playing catch-up. As a result, 7th- and 8th-grade teachers were ready for a change.

We compared these three standards-based programs to the programs we were currently using, and then teachers replaced units from the current curricula with one from each of the new curricula, to see how they would look and feel in the classroom. We produced correlations to the Massachusetts state frameworks, which had to be a consideration because we have to prepare our students for the MCAS[1] test. At the end of that second year, teachers came together and compared notes, filled out a questionnaire, and had building-level and cross-group discussions between all the 6th- and 7th- and 8th-grade teachers. That process logged a lot of input, both verbal and written.

Teachers reached a consensus to go with the *MathScape* curriculum. At least three teachers had worked with EDC during the development of *MathScape*, had done some field testing, and were comfortable with the program. *Connected Math* was the runner-up. However, the developers of *MathScape* were doing so much professional development that, quite frankly, we knew we had a support system nearby.

Transitions

Our elementary schools selected *Math Trailblazers* as their curriculum last year. We have a K–12 group of liaison teachers who met for a week-long summer institute in 1998 to look at the different standards-based curricula at the elementary, middle, and high-school levels. We looked at which programs most teachers really felt they could work with, and then looked at the fit between those. *Trailblazers* uses a laboratory method, where students observe, collect data, and display results in a variety of ways. You see a lot of those things in *MathScape*, too, so we felt the two programs would be a good fit.

At the high-school level, we're a little bit more traditional. We looked at IMP, *Core-Plus*, and *Connected Geometry*, but we selected more traditional texts. I think down the line, when we have some things in place, I'm going to want to go back and revisit those standards-based curricula, and maybe try to implement a program on a smaller level, to give students some options at the high-school level.

Eileen Herlihy has been the district mathematics coordinator in Waltham, Massachusetts, since November 1997. Before taking on that role, Eileen taught mathematics for 24 years at the middle and high-school levels in Waltham.

Waltham has eight elementary schools, two middle schools, and one high school. The total student population is about 5400, with 500 students at one of the middle schools and 400 at the other. While the district considers "middle school" to be grades 6, 7, and 8, because of budgetary reasons most 6th graders are housed in elementary schools. Only two schools send 6th graders to the middle-school buildings, so the population of 6th graders in the middle schools is quite small.

About 25% of Waltham students receive free and reduced lunch, but the income levels of families in the district span quite a range. Waltham is a western suburb of Boston, with a population that's roughly 33% minority, the largest group being of Latino descent.

[1] Massachusetts Comprehensive Assessment System. The test is criterion-referenced and contains a significant number of open-response questions.

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Implementation

All 6th-, 7th-, and 8th-grade math teachers will be using the *MathScape* program. During this current school year, two full units of the current curriculum were replaced by *MathScape* units at each grade level. So they've done a little bit of *MathScape*, but they haven't implemented fully. At the 6th-grade level, those replacement units were *What Does the Data Say?* and *Patterns in Numbers and Shapes*. At grade 7, the units were *The Language of Algebra* and *Getting in Shape*, and at grade 8, the units were *Looking Behind the Numbers* and *Shapes in Space*. There was a theme in choosing these units, to do some algebra and data work, and then something with geometry.

The teachers have created a plan for next year that they feel is doable—to implement four units, maybe five. Because *MathScape* looks very different from the traditional kinds of programs they've previously used, teachers need time to get used to it. We've created a timeline to try to do one unit in September and October, another unit in November and December, and so on for January through April. At the end of the year, teachers can implement any one unit of their choice.

They plan also to meet again next spring to revise those guidelines for implementation. We've made it clear that the guidelines are for one year only. We'll see how it works for a year, take the data that we collect from that experience, and come up with something more permanent. However, there will always be an ongoing review process for the curriculum guidelines.

Goals for students

One of the things that we would really like kids to do is be able to compute, but we need to move beyond that. We want to get kids to be really good problem-solvers, to think about what they're doing and what methods they're using, and be able to talk about it. We want them to become more than just symbol manipulators. Some kids are very good symbol manipulators—they can remember the algorithms. But they don't really understand *what* they're doing—they just know *how* to do it. We really want to get deeper into the mathematics, and see if the kids really can become problem-solvers, understand what's going on, and make connections to other areas so that the math comes alive. That's our biggest goal, to really develop students' problem-solving and critical-thinking skills.

Changes for students

The students seem to like the *MathScape* materials. They like the hands-on approach and working with the manipulatives. This year, I observed a 7th-grade teacher teaching graphing lines, and I was impressed to see the kids computing with positive and negative numbers and decimals. I noticed that so much of the skill-building was embedded in the lesson. I watched kids make mistakes and then work through them. I thought that was a neat way to learn the skills along with concepts, rather than just doing a page of practice. I think this particular teacher saw that, too. Sometimes I don't think the teachers see that the purpose of the curriculum is to embed those skills, rather than isolate those skills.

Mathematics

One *MathScape* unit I love in particular is *Roads and Ramps*. I show that one to high school teachers and say, "Take a look at what 8th graders will be learning! The kids study tangent, and they relate it to slope." I think *MathScape* does a par-

ticularly good job relating the algebra of lines with geometry. The program tries to do that really early on, by graphing lines in the 6th-and 7th-grade programs. *MathScape* does a really good job building that concept—the underlying information that gives the graph meaning.

MathScape materials

The *MathScape* book is set up and organized to promote student thinking and to provide a rich mathematical experience in a context that will spark kids' imagination and really engage them. That makes it look very different from a traditional math text, so it means a major shift in how teachers teach. I think our teachers are up to it, but I think they're a little frightened by it, and they see a great deal of work that has to be done next year and over time.

For instance, it's challenging for some teachers to find the homework in the layout of the materials. They're used to having students work on a section and then having homework questions on the next page, related to the skill taught in that section. In the *MathScape* student books, the homework questions are at the end of each unit and are organized by the level of understanding rather than by the individual skill. *MathScape* isn't laid out like a traditional math book.

One of the things that the teachers have said to me is, "Please make sure you get the *Hot Words, Hot Topics* book. It helps the kids and the parents make sense of the way *MathScape* is laid out." That book is easy to read, gives definitions, and makes things a little bit clearer.

Challenges for teachers

One of the things that we have to work through is the teacher's time involved in preparing lessons and correcting students' work. Correcting isn't quick anymore. Teachers don't just look at whether an answer's right or wrong; they have to look at answers a little bit differently. Teachers need to create lessons and performance tasks that will develop and assess critical-thinking and problem-solving skills. This takes longer than a procedural, drill-and-kill approach to mathematics.

Like any new curriculum during the first year of implementation, covering the material in *MathScape* units takes longer than teachers expect. We tell all the teachers, K through 12: "Look, we know it's going to take longer than you expect. We understand that." That's one reason why the teachers thought it was a good idea just to implement four units this year, instead of being pressured to do all seven units and maybe not get through them.

Professional development

We have provided teachers with ongoing professional development before and during implementation. One of the most unfair things we could do to teachers is just say, "We're going to do this new program in September," and not let them know what's coming at them. Recently I said to our assistant superintendent, "I think we really did this right." We really set a foundation for professional development before selecting a curriculum. Our NSF grant gave us the opportunity to start people thinking two or three years ago about where math education was going and what was happening in other districts around the United States. We looked at the goals of the Massachusetts Curriculum Frameworks and the NCTM *Standards*. So when we started to look at the new curricula, we knew what we were looking for. Even though it's still intimidating to teachers, I think they understand that our

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goal as a district is to develop critical thinkers and mathematical problem-solvers. Since we have given teachers support in this implementation, they have confidence that we will continue that support.

Once MathScape was selected as our middle-school curriculum, we asked consultants from the publisher and the MathScape Center to come out to Waltham and work with our teachers. These consultants are classroom teachers who have been using the MathScape curriculum with their own students. We decided which unit we were starting with—for example, in grade 7, *The Language of Algebra*—and before the Waltham teachers were scheduled to teach that unit, we had someone come to train them. The presenters gave guidance like, "This is what we're trying to get at here. This is important to do. This activity works. Sometimes this strategy doesn't work." Teachers got tips from colleagues who really knew the unit, who had used it with kids, who knew what was going to work and what wasn't. That was really helpful. We are planning to continue these workshops until teachers have received training on all the units.

Next year we're going to be implementing day-long, grade-level workshops for teachers, K–8. We have money in the budget for substitutes. For instance, we're going to have two day-long workshops where all the 6th-grade teachers can come together and talk, not with professional developers, but just among themselves. "Did you do *What Does the Data Say?*" "Yes." "How did you do it? What did the kids like? What did they get out of it? How did your kids do?" They'll be talking about math and picking each others' brains. I think that'll be helpful especially for the 6th-grade teachers who are so dispersed through the school system. Some 6th grades are doing departmentalized teaching, so a teacher may be the only person using *MathScape* in the school. They don't have another teacher to go over to and say, "This really was a disaster." We want to keep discussions happening system-wide.

So next year we're going to have four days of in-service—two days of training, and two days of coming up with their own ideas—and maybe redoing the curriculum guidelines for the following year. And then in April, we'll take another look: "What do you need for continuing professional development?"

Administrator support

At the end of the first year of implementation, teachers made it clear to me, as the district's math director, that they needed continued support in implementing the math curriculum. First, they wanted to carry through the training on all the *Mathscape* units. I questioned the need for this, given that they had just completed three years of professional development around the "big ideas" of mathematics through the *Reaching Every Teacher* grant. However, they convinced me that they needed professional development specifically geared to everyday implementation of the new curriculum. The teachers also expressed their need to have all the manipulatives and materials used in *MathScape*. I had some extra money in the budget so I purchased a manipulatives kit for each math classroom. I feel that it is my job to support teachers, to set expectations and help them to meet those expectations.

Assessment

Assessment is a big issue. If I'm going to have a goal for next year, it's going to be to take a look at current practices with regard to assessment. Teachers haven't found their comfort level yet with alternative forms of assessment, so they are cre-

ating their own assessments, ones that they feel more comfortable with. As a curriculum director, I need to be sure that teachers are using classroom assessment to inform instruction, and promote understanding and critical-thinking skills.

Challenges for administrators

There's never enough money in education. The percentage of kids we have on free and reduced lunches allows us some Eisenhower money, so we've had some money for professional development. But the *MathScape* teacher materials alone cost $10,000 dollars. When I was projecting my budget for next year and going through the publisher's catalog, I found that *MathScape* prices went up 50%. They used to be low, and now they're up to parity with everybody else, so it was a big jump all at once.

Things are going to be really difficult for me next year. There's so much change going on in Waltham. We're implementing the new math curriculum at the same time as we're moving to heterogeneous grouping in 7th grade, and then we'll phase heterogeneous grouping into 8th grade the following year. I'm glad we're doing it, but I don't know which is going to be the bigger problem for me—the new math curriculum or the new grouping system. I also don't know where there will be overlap in those challenges. I am hoping that the new curriculum will help allay parents' fears about the new grouping models.

Parents

We're trying to keep parents informed through the process. Parents knew that teachers were implementing just two of the units this year. One of the things that we said all year long when we were talking with parents is, "Look, we're putting in a new curriculum, and it's very rich. The concepts are going to be there. It's going to really address kids' learning styles."

The first impression that parents are having with *MathScape* is that it looks very different, and they're afraid. Parents are used to going home and helping their kids with their homework, and finding reminders in the textbooks of how to multiply fractions, how to multiply decimals. Now, to help kids with their math, they have to read through the lessons and try to work them out themselves. That's intimidating and, of course, it's more time-consuming. Next year, we're really going to have to do some parent workshops, with the help of the teachers. Also, giving the students those *Hot Words, Hot Topics* books to bring home should help some parents understand how they can help their students. Combined with the move to heterogeneous grouping, we're going to have to work through this change very carefully.

To parents who object, we can always say, "Look, this is what the state wants us to do. These are the kinds of things that the kids have to do on the state test. They have to be able to do the traditional skills, but they also have to be able to go beyond the traditional." What I say to parents and administrators is, "Give it some time. I think you're going to be surprised at what the kids can do in six months or a year." I'm learning that it's hard to get kids through at the beginning of implementation, but then all of a sudden you realize how much they know.

Equity

With our National Science Foundation grant, one of the things we looked at was equity issues. We took a long, hard look at ourselves in Waltham, and what we were doing for our students. I think one of the reasons we chose *MathScape* and

chose to go to a heterogeneous grouping model is because we weren't serving some of the minority kids the way we should have been.

I have a 6th-grade bilingual teacher, one of the teachers who was not on board with *MathScape*. She said, "My kids can't do this. It's too much reading." But she came in to me one day with one of the lessons and said, "The kids saw so much more in this lesson than I did." And then she told me, "I said to those kids 'I have been unfair to you. I didn't think you could do this, and you showed me you can.'" It was a powerful conversation.

I think *MathScape* addresses different learning styles, and some teachers are very surprised at what kids can do. Some kids who don't perform well on pencil-and-paper tests can see a problem in a different way and work through it. We have two teachers in the 8th grade, a regular classroom teacher and a special ed teacher, who have worked out an inclusion model. They understand that some of their special ed kids have come so much further in mathematics than they would have if they had not been exposed to *MathScape*. That's one thing that I think is truly a strength of the program. ■