MATH CONNECTIONS:
A SECONDARY MATHEMATICS CORE CURRICULUM

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Three years of high school mathematics curriculum.

The vision of *MATH Connections* is that all students can learn mathematics. *MATH Connections* is a complete three-year high school curriculum for all students that has as its mission the conceptual development of the learner. Using the NCTM *Standards* as a guideline and replacing traditional Algebra I, Geometry, Algebra II, *MATH Connections* blends the mathematics of algebra, geometry, trigonometry, probability, statistics, and discrete mathematics. As its name suggests, the curriculum bridges connections of all sorts: those between different mathematical areas; mathematics and science; mathematics and other subject areas; and mathematics and the real world of people, business and everyday life.

MATH Connections is concept driven. That is, concepts are introduced in the context of real world applications, problems and projects. Rather than teaching a single topic, *MATH Connections* uses broader concepts to link topics together in a unified, interconnected approach.

MATH Connections is designed to provide students with experiences that excite their curiosity, stimulate their imagination, and challenge their skills. The pedagogical approach of *MATH Connections* is flexible. It is intended to meet the needs of all students by making a concerted effort to accommodate a variety of student learning styles and levels. The materials support a combination of teacher-student and student-student interaction, hands-on investigations with prompts for class discussion, individual activities and student writing and justification of results.

Student assessment in *MATH Connections* includes written, oral, and demonstration formats that assess higher order thinking skills. In this way, students demonstrate their mathematical skills, their approach to non-routine, real world problems, and their understanding of mathematics concepts and how they relate to one another.

The curriculum integrates technology through the use of graphing calculators and computers, which students use to make conjectures; validate findings; and investigate concepts, problems, and projects in greater depth. The program encourages students to use these tools when appropriate. Discussions of how the tools work, why they work, and whether or not they are appropriate for a particular task occur throughout the course.

The Student Edition is published in six half-year, hardbound textbooks. The Teacher Edition is organized in half-year sections to accommodate different teaching styles and traditional and block scheduling. The *Teacher Resource Pack* includes the Teacher Edition, a replica of the Student Edition, a Teacher Commentary which is correlated to the Teacher Edition and provides professional development; Blackline Masters for use as overheads or classroom handouts; and a full set of Form A *MATH Connections* Student Assessments with Solution Keys and Scoring Guides.

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JUNE ELLIS ▸ DEVELOPER

Dr. June Ellis is the Principal Investigator and Director of the NSF-funded projects *MATH Connections: A Secondary Mathematics Core Curriculum* and the *MATH Connections* Implementation Center. Previously, she was Principal Investigator and Director of the NSF-funded Secondary Mathematics Core Curriculum Initiative. Dr. Ellis is also the senior member of MATHconx, LLC, which works with both the curriculum project and the implementation center to help strengthen students' mathematics education and teachers' professional development.

Prior to these NSF awards, Dr. Ellis had a varied career in education, business, and industry. She was a secondary-level mathematics teacher, and an administrator who directed the implementation of innovative curriculum in the Dade County (Florida) public schools. She has been an associate professor of mathematics and is the co-author of several mathematics textbooks. During her 12-year tenure at The Hartford Insurance Group, Dr. Ellis was the Director of Technical Education, where she introduced distance learning for 50 regional offices.

Dr. Ellis received her bachelor and master's degrees from the University of Miami and her Ph.D. from The Florida State University. She was recently the first recipient of the Lifetime Honorary Award by the Instructional Design and Development Institute of The Florida State University.

The vision of *MATH Connections*

The vision that spurred the development of *MATH Connections* is that all students can learn mathematics, be critical thinkers and be problem-solvers. Our mission was the conceptual understanding of the student. Our primary goals for the curriculum were established by the principal investigators, myself included, with the developers and an advisory council of mathematicians, scientists, mathematics and science educators, and business people. What we wanted to do was bridge the worlds of education and business for students, through mathematics. We wanted to increase the mathematical power of all students and empower them for their own learning. All of us who worked on the project agreed that all students can learn mathematics; there is just no question in our minds about that. We wanted to develop a core curriculum that would reflect the NCTM *Curriculum and Evaluation Standards for School Mathematics*. We also wanted to empower teachers to meet the NCTM *Professional Standards for Teaching Mathematics*.

Our mission was to help students develop conceptual understanding by learning mathematics in real-world situations, so that they could begin to perceive that mathematics is useful to them today and useful to them in days to come. We also wanted to increase their confidence in the fact that they really could learn mathematics. *MATH Connections* is built around connections of all kinds that bridge mathematics with the real world of people, of business, and of students' everyday lives as well. It also builds bridges between different mathematical areas. We feel that our program blends mathematics in a seamless way so that any one problem may involve several different areas of mathematics. It builds connections with other subject areas as well—between math and science, history, geography, language, art, and music—any number of topics that connect with the students' curriculum in school as well as what goes on outside of school.

For example, in the beginning of the first *MATH Connections* book, there is a problem that blends mathematics with botany and studies from outer space. The problem reads, "To learn the ways long trips in space might affect living things, NASA sent 13,000 tomato seeds into an orbiting platform for five years. The seeds were identical to the Rutgers tomato seeds you can buy in any hardware or department store except that they were launched on the shuttle, orbited for five years and then recovered. The seeds were next sent to schools all over the country to grow and to be observed. The first seedlings grown from the space seeds and seedlings from usual seeds were measured in centimeters." Then, in the materials, we show the measurements from one school. The data is from three-week-old seedlings—both the earthbound seeds and the space-exposed seeds—and we ask students to make dot plots of the four lists of measurements, and to mark the mean for each one. Students then analyze the data to determine the differences. We ask them to make some forecasts about the next generation of plants, given some additional box plot data about those plants. What this kind of problem does is give students some valuable experience in using experimental data and a chance to learn about the frustrations of doing real science in the real world. In this particular problem, we have them use their understanding of statistics in terms of measurement of the median range and quartiles by constructing box plots and comparing data.

The *MATH Connections* curriculum

We try to help people understand that in *MATH Connections*, they are not going to see the mathematical topics in the order in which they have traditionally seen them. For instance, we try to help people understand that they are not going to have Algebra I in Year 1. They are going to see some traditional Algebra I topics—for instance, students are going to be able to work with two variables—but the mathematics itself is blended across the whole curriculum. We start concepts earlier than in the traditional curriculum and carry them throughout the whole program. For example, we develop the concept of function in the first year, and the topic of function then appears and is further developed throughout the entire *MATH Connections* curriculum. Teachers tell us, in another example, that we do an outstanding job with slope. That is another concept we start in Year 1, and it goes on throughout the entire program. When our students finish the third year of *MATH Connections*, they are prepared for any senior course, whether it is Precalculus, Calculus, AP Statistics, or any other senior course. We feel it should depend upon the student to make the decision as to what they want to take when they are going ahead.

We did not put a lot of practice in the books themselves—we instead included extra practice in the supplementary materials. We felt it most appropriate to give the students meaningful problems to work on, in which they could use what they had learned to solve the problem. There is a lot of skill development in solving problems—you cannot go to the calculator and get an answer if you don't know the mathematics. The problems provide technical skills; there is no question about it. But they also provide more. Students explain what they did in solving the problems. They answer questions about their work. They justify their answers. They have to write paragraphs to explain their thinking.

While we were developing the curriculum, we had 10–15 high-school mathematics and science teachers who would come to Connecticut to work with us in the summer for four to six weeks. They would review our work, sit in on discussions about the program, and make suggestions for keeping the material at a high school level, even when it was higher mathematics. They would also suggest problems and projects to add to the program. So teachers were reviewing the materials and making suggestions during the development. They also wrote supplementary materials for students who might need some additional practice. Our senior writers—professors of mathematics—also wrote extensions of particular topics that students might have an interest in. For example, in Year 1 there is a section that deals with problems in paleontology. The extensions take the student even further into the topic of paleontology itself, as well as the mathematical topics that are entailed.

Technology

Calculators make a big difference for students because they can go into further depth and breadth with a problem than they could if they had to sit there calculating by hand over and over again. As long as they have had experience doing it by hand before they use the calculators, they get a real understanding of what needs to be done. I would say that it would be unfair to the students not to provide them with graphing calculators to use with *MATH Connections*. When we first started the program, many teachers had never even seen a graphing calculator, let alone used one. Now, more and more teachers are using them in their schools already.

We found from many of the teachers in the beginning that the management of the graphing calculators was a big thing. They had classroom sets—so students

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couldn't take them home for homework. In talking with the teachers, we suggested to them that they might think about having students prepare a problem for homework because there are a lot of decisions you have to make about a problem before you can use your graphing calculator. Then, when students came into class, they use the graphing calculator to complete the problem. In some cases, once parents understood that there was a graphing calculator for use in the school, they would buy a graphing calculator for their child to use at home, knowing that it was not going to get lost or taken.

Some schools use computer programs, such as Excel, with *MATH Connections*. As part of the professional development institutes we do, we use the Geometer's Sketchpad. Key Curriculum Press was kind enough to provide our field-test sites with the program. For those schools that have computers, we have many places where we suggest that using the Sketchpad will work really well. The computer is not, however, required. At the time we were writing the curriculum, there were still not many schools that had computers, so we couldn't require their use.

Professional development

We have weeklong Summer Leadership Institutes for teachers who are adopting *MATH Connections*. A teacher might start out teaching 9th-grade *MATH Connections*, and would come to the 9th-grade institute for a week. The following year, if they were teaching 10th grade, then they would come back for another week, and so on. In between the summer institutes we have what we call Academic Year Institutes that meet anywhere from four to six Saturdays during the school year.

In the institutes, we are trying to help the teachers learn the mathematics as well as understand the pedagogy of the program. Some teachers have not taught Trigonometry, or Algebra II, or maybe have not taught these classes for many years. Some of the teachers have never had statistics, or if they did, they had it a long time ago. We also work with teachers on using the graphing calculator and the software.

We start off our institutes by helping teachers to understand our vision and the mission of the program. We try to simulate the classroom so the teachers become students in our classroom. We want them to have a really good understanding not only of the mathematics, but what it takes to do these problems. They need to have a feeling for what the student is going to go through and to understand that there are going to be times when a student is going to do something in a problem entirely different from the way the teacher would have done it. We pair teachers together, and they discover that their partner may solve problems quite differently than they do. They begin to understand that it is the assumptions on which you base your work that make your answer possibly different than your partner's answer, and both might be correct based on different assumptions. There is a lot of open-ended questioning that goes on during the summer institute.

In the summer we take them through the first semester of the materials—they might go through Chapter 4, say. In the academic year, we keep moving with them, always a little bit ahead of where they are in the textbook. During the academic year, we encourage them to interact with each other and share their ideas. "I have this problem. I just don't know how to handle it. Has anybody got an idea?" Somebody comes up with, "This is what I did..." We want teachers to see, through the professional development, that all students can learn math. It depends on whether you believe in them, whether the material intrigues them, whether it is challenging to them, and whether they can become excited about it.

Implementing *MATH Connections*

When a school is interested in *MATH Connections*, very often our publisher, along with experienced teachers who instruct our professional development, will go and meet with the math department, the superintendent, the principal, and the curriculum director to talk about the program. We talk about our vision and mission and what our evaluation shows. We speak with them about their interests, and what it is they would like their students to be able to do when they graduate from their high school. Nine times out of 10, their objectives are really the same as ours. Many schools have found that the traditional programs just are not working.

We recommend that schools implementing *MATH Connections* start with the 9th-grade students first. Don't start with the 10th- or 11th-grade program right away, because the topics don't follow the traditional Algebra I/Geometry/Algebra II sequence. Students will need the background from the 9th-grade program, so we recommend that the students start the program in 9th grade and then move to 10th and then to 11th. We have, however, had some success with schools that wanted to start with the 10th-grade program right away. In those schools, the 10th-grade teachers took a week of the 9th-grade professional development institute so they would know what the students should have, and could supplement it themselves, and then also took a week of the 10th-grade institute. That has worked very well.

Connecting to parents

We recommend to schools using *MATH Connections* that they have a meeting with parents of 8th graders—before students come to the high school—to talk about the program, to answer questions, to show them the graphing calculator, to show them the books. We have a booklet for parents, answering questions most often asked by other parents. We have material that the people who are directing the meeting can use to answer questions. We try to be available if the school wants us there, or we might have a conference call with them to answer questions. We also suggest that during the school year, they have a meeting in October with parents of *MATH Connections* students so that they can see how it is working. At that point in the school year, the students have done enough with the curriculum that the teachers can answer questions and talk about the progress the students are making with their parents. We also suggest they have at least one meeting with parents in the spring. Some of our schools have now started one-page, two-sided newsletters about *MATH Connections* that they send out every quarter to the parents of all the students in *MATH Connections*. The newsletters tell parents what students have done, how they are moving along, what the plan is for the next quarter, and so on. Schools should definitely keep the parents informed.

We try to be open with parents, and recommend that schools do too. We will answer any question a parent asks. After meeting with parents in one school, I received a phone call from a father of one student who asked, "What good is this going to be for my child? He wants to be a paleontologist." I opened the book and I read to him a problem from the curriculum that related to paleontology. He asked, "Do you have other problems like that?" I said, "Yes we do—they may not relate directly to paleontology, but these are the kinds of questions we ask." I gave him the page number of that problem so he could look in his son's book, and that answered his question. Another man questioned our approach to a certain problem and why we had students thinking about it in a certain way. He asked, "So why did you do that? I could do it just with plain algebra." I said, "We want the student to see all the different ways a problem can be solved and this is a particular way that leads into the next topic." "Oh," he said, "that is a good idea."

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Data on the impact of *MATH Connections*

We have always had an external evaluator for *MATH Connections*—somebody who was in no way connected to the project. That evaluator looked at what teachers, parents, and students would want to know about *MATH Connections* and whether or not it was reaching our goals. The evaluator looked at how *MATH Connections* students performed on independent, standardized, mathematics achievement tests in comparison with non-participants. The evaluator looked at the extent to which the participating students achieved the objectives of the curriculum as indicated by their scores on curriculum-specific tests; achievement related to the characteristics of student gender, ethnicity and special education levels; and students' attitudes towards mathematics and mathematics learning compared to students not in the program. We also wanted to know what *MATH Connections* classrooms really looked like, what their basic structural characteristics would be: the student grouping practices, the extent of cooperative learning, participation across genders, and the nature of students' mathematical thinking and applications.

To answer these questions, the evaluator looked at pairs of students with comparable mathematics ability (according to their results on the Connecticut Mastery Test, taken in the fall of Grade 8, and considered an incoming high school mathematics ability measure) within a school, comparing students in the *MATH Connections* program with students who were not. The evaluator looked at the Connecticut Academic Performance Test, the CAPT test, taken in the spring of grade 10. We looked at the PSAT, which is generally taken in grade 10 or 11, and the SATs, which as you know are usually taken in grades 11 and 12.

On the CAPT test, 60% of the 558 *MATH Connections* students met or exceeded the state goal, compared to 55% of the 745 non-participants. This is a statistically significant difference. The conclusion of the evaluator was that, considering all the results on the CAPT performance together, there was a clear trend that the *MATH Connections* students performed better on the CAPT than their non-participating peers. On the PSAT, there was a tendency for the *MATH Connections* students to score higher on the PSATs in both mathematics and verbal than the non-participating students, although this was not statistically significant. However, on the SAT, the students scored higher in both mathematics and verbal, with statistically significant differences.

In another study, students in a diverse urban residential community completed a formal survey of their confidence in mathematics and their perception of the usefulness of mathematics. One of the reasons for doing this study was that everything we had read on the variables in the affective domain indicated that students' beliefs and attitudes, confidence, perseverance, and emotions play a central role in mathematics learning. Their attitudes towards mathematics often affected their decisions to enroll in higher-level math courses—which was something that we hoped would happen.

That study looked at three groups of students. One group had a *MATH Connections*-trained teacher teaching the *MATH Connections* program. The second group had a *MATH Connections*-trained teacher teaching Algebra II, which happens because sometimes not all of a teachers' classes are *MATH Connections*. The third group had a teacher not trained in, and not teaching, *MATH Connections*. There were statistically significant differences between the three groups with respect to their confidence in learning mathematics and in their perception of the usefulness of mathematics. The results were most favorable toward Group I. But the results were also

favorable toward Group II, in comparison to Group III. What we think happened—and teachers have confirmed this—is that they carry over the professional development and the teaching approaches from *MATH Connections* into their other classes. They even bring some problems into their other classes. They are changing their teaching behavior, not just for *MATH Connections*.

In another study, evaluators observed *MATH Connections* and non-*MATH Connections* classes—with comparable students—in the same schools. They mapped out the basic classroom structure, looking at whole-class activities, small-group activities, and individual seatwork. *MATH Connections* classes had more small-group activity, and *MATH Connections* students engaged in a fairly high level of cooperative learning and were significantly more on task. There were more complex cognitive levels of discourse among both *MATH Connections* students and teachers than in the comparison classes. According to the evaluator, the contrast in discourse was striking, with the non-*MATH Connections* discourse being at a lower cognitive level. The *MATH Connections* teachers and their students also made statements and asked questions that evoked a broad range of reasoning, communicating, and problem-solving. The wide range appeared more uniformly among the *MATH Connections* classes than it did in non-*MATH Connections* classes. Finally, they found that *MATH Connections* classes provided the same type of opportunities for students of both genders.

These kinds of activities are built into the *MATH Connections* curriculum. We explain the mathematics for those teachers who might need to know what different ways the problems might be solved and that type of thing. We include problem-solving tasks for the classroom, for the small group, and for students writing and explaining their thinking, and it all came out in these observations. ■

HELEN CROWLEY ▸ MATHEMATICS TEACHER

Helen Crowley teaches *MATH Connections: A Secondary Mathematics Core Curriculum* at Southington High School in Southington, Connecticut. She's been involved with *MATH Connections* for five years, since Southington began piloting it with a small group of 9th graders in the second year of the program. Ms. Crowley has taught all grade levels of *MATH Connections*.

Southington High School is a four-year school with approximately 500 students in each grade. It is the only high school in its district. The school population is largely middle-class Caucasian students, many of whom are college-bound. Ms. Crowley has taught high school for 22 years. While most of her experience has been in mathematics, she also taught physics early in her career.

Why *MATH Connections*?

We needed a change. We had followed the work done at NCTM and were looking for a more standards-based curriculum. We were offered the opportunity to work with the *MATH Connections* curriculum and have some impact on its development. People tend to talk about the failure of the first "new math" and the fact that teachers weren't taught how to use it before implementing it. Part of our choice of *MATH Connections* was the fact that professional development was available to us at very little cost—it really was a way for us to get some essential professional development. Some of the technological support that came along with it was another part of our reason for selection. The program had all the qualities that we were looking for in a reform program.

The major strengths of *MATH Connections* are applications and the writing orientation of the program. The fact that students become engaged in a problem over a period of time helps with the development of a concept. I like the way the text flows.

The basic approach of the program is to present students with a problem that is pretty practically-oriented; generally, we're given some kind of problem and then we look at how we're going to solve that problem and what mathematical techniques we can bring to that problem. For example, in the 9th grade they look at building a ramp, look at the supports for the ramp and what the size of the supports will be, etc. A lot of their initial work with solving equations includes things like working with an electric bill; for instance, students are given certain information on the bill and they're given a certain situation, and are asked to solve a problem using an equation. In terms of geometry, there is more work with three-dimensional, spatial kinds of figures, and volume—which were never taught in traditional texts. An example of a geometry problem developing the concept of area is building a go-cart track. Students figure out how much asphalt they'll need to cover the surface of the track and how much grass they'll need to fill the inside of the track, and they're working with the curve of the track.

Mathematics

I think *MATH Connections* does really good work with functions and with database development of all kinds. Every chapter does some kind of data collection, fitting some kind of function to the data. There's coordination between the algebra concepts and the geometry concepts. In the Algebra II year, there is time spent with families of functions and how we transform them, and their domains and ranges. Kids become much more conscious of how that all fits together. The whole development of slope and the equation of a line is approached very much from a transformational point of view: What happens when you change the slope of a line? What happens when you change a line?

The whole concept of proof doesn't really come up in the program until the end of the third year, which is Algebra II. Many of us don't get into that part of the book before we finish Algebra II. So in a three-year sequence, students see very little of proof in the traditional way. I don't know whether they need it or not. I always struggled when I taught it to sophomores.

Instructional approach

I've found that pedagogical approaches that engage my students work best in the classroom. In the last several years I've used a lot more cooperative learning, and have asked students to give explanations for their work, because that forces them not only to focus on what they are doing but why they are doing it. I encourage much more interaction and questioning in my classroom. Once or twice a week I walk around the room and ask each student if they have questions; I find this encourages them to ask questions that perhaps they wouldn't have asked in front of the whole class. I've also engaged them in a lot of interactive things, like more technology-based explorations where they are asked to look at what is happening in a situation, develop some understanding of a pattern, and test it out.

I want my students to like math, or at least not dislike it. I want them to be a little less afraid and more comfortable with it. I want them to have the ability to talk about what they are doing, because it gives them some understanding of why we are doing things. Looking at applications with them is really important, instead of just trying to teach them information; they can now look at a set of data and be able to analyze the data.

One of the complaints that we hear from students—and I'm not sure how I feel about this—is that there are not enough examples in the text for students to go back to see how to do things. They talk about that in terms of homework, and I think it means that they can't go back and copy how somebody else did it. Parents sometimes say the same thing, that they want to go back in the chapter and see how to help their child, and they can't necessarily find it.

I've also engaged them in a lot of interactive things, like more technology-based explorations where they are asked to look at what is happening in a situation, develop some understanding of a pattern, and test it out.

Implementation

Most of our population now takes the *MATH Connections* curriculum. We use *Connections* now with all of our students in the two middle levels: one that is more clearly college-bound, and one that struggles a bit more. We haven't done it with our honors group or our lowest group. However, some of those teachers who teach *MATH Connections* at the middle levels also teach the honors course, so we are seeing more of the *Standards* concepts integrated in the honors courses. There is talk of integrating some of this work into our lower, more remedial level, but we haven't done that yet.

When I started with *MATH Connections* I was a little skeptical about whether the approach would work. Now I would never want to go back to teaching any other way, and I wish we had more time to use it. When we bring in new things we have to let go of some things. I don't know that we will always use this textbook, but certainly the concepts that are here are working so much better than what we used to do. I've become very convinced that this is the way we need to go.

Supplementing the curriculum

Individual teachers do their own supplementing in areas where they find it necessary, but we primarily use *MATH Connections* for Algebra I, Geometry, and Algebra II. Since some colleges have followed the reform movement and others may not have, we are currently redesigning our Precalculus course to add some areas that *MATH Connections* doesn't spend a lot of time on, to try to bring students up to par with what we think colleges expect. We used to use a fairly traditional text with a lot of manipulation but not much applied problem-solving.

What's challenging about teaching with MATH Connections is that you always have to feel comfortable with the topic. Sometimes the direction that students will take a problem is not the direction you were thinking about initially; it takes a great deal of preparation to be ready for that.

There are areas in which students need more practice than what the text provides. There are new supplementary materials for *Connections* coming out, which should provide worksheets, additional reinforcement, and enrichment. In the first year of the program, kids need more practice with some of the traditional things. I've only used pre-publication versions for Algebra I, but I hear teachers who are using the newly-published version still talking about some areas where students need more work with manipulation of variables, or with exponents or factoring.

It's challenging for teachers to come up with additional problems. Our teachers have developed a system where, if we need to supplement something that is important, we try to share information. Someone will develop a project for one chapter and they'll share it with the rest of us. We like to say that we chose this text because it did pretty much what we wanted it to do, but we've never found a textbook that did everything we wanted. We've always needed to do some kind of supplementing.

Training for teachers

Summer training sessions are very helpful; we basically go through the text from cover to cover. The instructors pair up and go page by page, pointing out what might be different than what teachers are used to teaching, or places where we might want to put more emphasis. Rather than trying to work through the book during the school year, when we don't have lots of time, it's easier to have the opportunity to do that during the summer when we really are freer to focus on those things in depth. The summer institutes run for a week and then there are one or two sessions during the school year. The institutes try to give an overview of every chapter, allowing people to actually work through some of the exercises. That is another thing that really benefits us, that we wouldn't necessarily do otherwise. During the school year, I might look at an exercise and assign it to students without trying it first. In the summer institutes, instructors try to select difficult problems and have the teachers work through them. Then you're in a better position to decide whether that is something that will work for your students. In the first year, when we did the summer training, there were more sessions that dealt with pedagogy than there are now. The goal was to practice. Certainly that was one of the places that I was really encouraged to try working with cooperative groups.

It is very helpful to have contact people who can help with problems, particularly if they're someone who has been through it before. We had a lot of support because the developers were right nearby, but also because we got to know other local districts that were using *MATH Connections*. You know, I might see somebody from a neighboring town and ask them how's it going and what they're doing, where's it going next and that kind of thing. I think that kind of support is important.

Changes for teachers

What's challenging about teaching with *MATH Connections* is that you always have to feel comfortable with the topic. Sometimes the direction that students will take a problem is not the direction you were thinking about initially; it takes a great deal of preparation to be ready for that. The emphasis on writing and the use of alternative types of assessment are not the types of grading many of us are used to. We are used to seeing solutions to 20 problems, and deciding whether they are right or wrong. Using this program, we sometimes struggle with how much credit to give here, or what kind of rubric to develop there.

MATH Connections has gotten easier for me over the years. We got a lot of encouragement to change, and having a whole new curriculum helps you change your approach. It required me to change my whole style of teaching, and that takes time. In our first year, we were looking at another school that was piloting *MATH Connections*. Those teachers talked about the fact that their students were more engaged and less likely to be clock-watchers and that teachers were also less likely to be clock-watchers. That tends to be true; now I watch the clock to make sure I can get everything done by the end of class. As much as the program is a challenge, to me it's also a benefit because I find teaching more enjoyable then I did seven or eight years ago. I have a lot more fun with the math and it keeps me thinking all the time. I enjoy playing back and forth off of the students.

To me, one of the great benefits of the program is that it's technology-based. The kids are involved in more exploration-type activities. But if you're one teacher in the computer lab trying to watch 25 students who start running into problems, that becomes a challenge. Initially there's a lot of unfamiliarity with the technology, even the graphing calculators. When we first started, teachers were running down the hall to get help. It's a challenge to learn the technology and be comfortable enough so that when students make mistakes or get into a bad place, you can help them.

We had some discord in our department (and we still do) about whether this is the way we want to go. But we figured that if we didn't change, we weren't doing the best we could, and that any change would probably be a good change. Some teachers are worried that we are letting go of too much of what we traditionally did, and that students will not function as well without some of that traditional mathematics. For instance, the whole approach to proofs and the drill work on manipulation of data are areas of concern. Some are concerned that we may be going through one of those math phases that will phase itself out, and that we will have used some of our students as guinea pigs. But we knew we needed to work more of the technology and the whole writing component into our mathematics classrooms. Connecticut now has the CAPT (Connecticut Academic Performance Test), and this was definitely a curriculum that would align with that test. *Connections* students are asked to do more writing, problem-solving, and work with technology. Our data comparing students using *Connections* and those using the traditional program really shows that those using *Connections* are doing much better.

Impact on students and parents

Students who are going into a college program that is taking a reform approach do very well. But we still hear that there are colleges where students are not allowed to bring in their graphing calculators or where teachers will say you can use the calculator except on a test. So those students struggle a little bit. We try to bridge that in our precalculus year, by teaching them more factoring; actually we've distributed that all the way across the curriculum. There seems to be an expectation from colleges that students are able to do those kinds of manipulations, but that isn't a focus in the program. I make my students crazy because on part of my tests, I don't want them to touch their calculators. In addition to knowing how to use technology, they are also expected to know what they are doing without relying on the calculators. For some students, their preparation in the *Connections* course was just right for college and they're doing very well; other students are struggling, and the expectations for them are different than what they were prepared for. This is the first year that our students have been in college, so we're getting spotty feedback. One student says she is popular in her dorm for helping everyone with math, sharing all she knows about the technology that others haven't had experience with.

As much as the program is a challenge, to me it's also a benefit because I find teaching more enjoyable then I did seven or eight years ago. I have a lot more fun with the math and it keeps me thinking all the time.

In terms of looking at statistics, I can say that most of what we have done locally seems to show that our students aren't just guinea pigs. On the state tests and on the SATs, students are holding their own. That was a big concern, because administrators, teachers, and parents were really concerned that there would be things on the SATs that *MATH Connections* kids would not be able to do. I think there are, but these kids have some additional problem-solving skills, so that while they might not solve some of the problems in a traditional manner, they have an approach to solving them. I also think that they have learned how to do some problems that they would never have been able to do with a traditional background. So I think somewhere along the way there is a tradeoff.

Parents have been concerned along those lines and also along the lines of colleges. They wonder whether their children will be able to get into college with this new curriculum. Sometimes people read the name *MATH Connections* and they think that it's "lower level," so that is a concern. Parents want their students to get a good education in high school but they also want their students' high school mathematics to get them into a good college. Parents are concerned that that won't happen with this course. So far that has not been true. We've had a couple of meetings with parents where we've addressed the entire curriculum and what it is really all about. We have many parents who have proven to be supportive once they have been informed about the course.

Meeting the needs of different learners

We don't have a lot of diversity among our students. Looking at the gender equity issue, females do pretty well with the program because it is different, probably because they can do more writing and questioning and explaining. We've had a number of special education students enrolled in *MATH Connections*. They've had to struggle more with the reading, because for many of them that's their weak area anyway. Also for students for whom English is a second language, reading and writing is often a struggle because of the language base of the program. Lots of kids have needed more support in working their way through the reading and writing in the program. I do think that overall they have found more of a comfort level than they did in traditional math courses, since they are allowed to be more interactive here. ■

LARRY OLSEN ▸ MATHEMATICS TEACHER, GRADE 9

Goals for students

My ideas have changed a lot with the perspective of 38 years in the classroom. I see less and less of a need to prepare our students for calculus and for college mathematics, and more and more a real need for preparing students to go into a work environment. A school-to-career approach to teaching seems to be a mode that I'm moving into a great deal more. One of the things that I like very much about *MATH Connections*, and that I've begun to embrace the longer I've been involved in the program, is the fact that everything in this course is taught in contexts that provide good reasons for studying these things.

To be mathematically literate today means something entirely different than it might have meant a decade ago, or certainly back when I began my teaching career. When I began my career, it was good enough to be able to perform your basic operations. To be mathematically literate today means that we've not only got to interpret data, but we've got to be able to live in a world that involves an awful lot of technology. We need to understand that when we're dealing with technology we have to be able to interpret our results there as well.

Also, there's very definitely a need for all of our students to be literate algebraically. That means they've got to have a degree of comfort with a number structure and an ability to think of unknowns while they're describing the activities that they're involved in. So much of what we do can be put into the structure of algebra. We also are bombarded daily with data in the media. It's certainly to everybody's advantage to really be able to receive that data and analyze it, to see whether it makes some sense and to have an understanding of what the media's trying to present to us.

Why *MATH Connections*?

As a district curriculum coordinator and also the high school department chairman back in the late '80s, I was very actively looking for an integrated curriculum. I was dissatisfied in general with teaching the mathematics in isolated clumps that stood disjointedly next to each other.

Within the state here, *MATH Connections* was more like a homegrown curriculum. It looked like a wonderful vehicle to present us with an integrated curriculum. Many integrated curriculums I've looked at simply pick up some chapters out of geometry and put them in an algebra book and call that integration; I liked the fact that this didn't do that. I found that this not only integrated the topics of mathematics, but that it was integrating a lot of the academic disciplines in this material. Just about any place you looked in the textbook, it was obvious that students needed to be able to read and write; it was a subtle way of teaching a lot of social studies and general information. For instance, there were these charts that had to do with the medical fields or sporting statistics or population figures. The focus was, perhaps, on exponential functions, but they were coincidentally looking a little bit at the growth of population in the country, recognizing how the state of Nevada has grown in population compared to some other state, and wondering why that is. There was such a plethora of activity and conversation built into most of the topics that were presented in this textbook. Those were the kinds of things that made us very curious to look further into it.

Larry Olsen is a veteran of 38 years of teaching. He has taught four years of *MATH Connections* in 9th grade in Manchester, Connecticut. Larry spent much of the previous 10 years teaching Precalculus. He has also been a curriculum supervisor in his district.

Manchester is a community of 50,000–55,000 people. It's a retail and bedroom community for Hartford, and has become much more urban in the last 15 years. Presently, the student population consists of 35% minorities, with growing diversity in the community and schools.

I'd say the most significant strength of the program is its automatic tie-in with the work world around us, the fact that almost everything is taught in context.

So then I began to bring some people to my school district to talk about it with my staff. Not all of my staff bought into this, but we had a great number of people who were very much proponents of this as an exciting way to teach mathematics. That led us to the point where, when they provided us the opportunity to pilot, we got ourselves involved on a very small scale of about 60 or 80 students. We've consistently grown since then. *MATH Connections* is not the only way to go in math education in our school district, but we probably have maybe 800 students who are in *MATH Connections* this year, out of a population of 2000 students. Courses are taught homogeneously in our school district, and it's not unusual for the students at an upper level to be taking four years of mathematics. We're now finding that students who are at one of the lower group levels are also taking four years of mathematics while they're in this course. So we feel like we must be winning in that regard.

Strengths of *MATH Connections*

The basic approach of the program is that it almost says, "Let me show you that there's a need. Now that we recognize that there is a need for this type of mathematics, here's a way we can do this." For example, interpolation and extrapolation, and lines of best fit are topics that have never been in an Algebra I course. In this particular course, for instance, we see a need for the ability to find out what happened between 1940 and 1948 based on all the surrounding data that we've got. The materials basically say, "Oh, by the way, this is called interpolation, but there are a couple ways we go about finding out what takes place. Now, here's a tool that we can use to accomplish this." I think that's really a sly way that these materials introduce topics.

There are some very common threads that run through all three years of these materials. They're nice to use at every point along the line because they provide this string that helps to tie all the content more closely together. One of the things I love about the materials themselves and the problems and activities that are described is that we have a cast of characters present throughout the textbook. They're both male and female, and they certainly cover the spectrum of diversity. We've got applications that come from all walks of life, like the medical profession, athletics, you name it.

I'd say the most significant strength of the program is its automatic tie-in with the work world around us, the fact that almost everything is taught in context. At the 9th-grade level, where I've been doing my teaching, I've never heard anybody say, "When are we ever going to use this?" because it's obvious. Data collection, display, and analysis seem to be very prominent pieces of all of the new programs that are out there, and *MATH Connections* is certainly no exception; they're very strong in that regard.

In my grade level, the treatment of functions and the way that slope is introduced is very rich, as is the concept-building in straight-line linear behavior. It takes a lot of time, but if you keep at it, you begin to see that, gosh, these materials just come at these kids from all different avenues. If the kids are alert and really hearing and seeing all of this, then they come away with a very solid background in linear functions.

Opportunities for group work and group activities are built into the program; they're highlighted on most pages with a lightning bolt or cloud graphic that says "Do This Now!" or "Discuss This." That makes it easy for a teacher to identify those places where we could step back and ask the students to talk in groups and come to some conclusions on their own.

Instructional approach

Concept development is done in a lot of circuitous approaches, so concepts are going to come up again. It's probably Chapter 2 in the 9th-grade book where we first see any equations at all. An equation appears, which happens to be an exponential equation, but nobody ever calls it an exponential equation, and no reference is made at this point about what it is that makes this particular equation different. Maybe some kids will recognize it's a different-looking equation and we'll talk about it a little bit, and we'll use our graphing calculators to find values, but we certainly won't say that this is a non-linear function. That's never been brought up. Where we do have some linear functions, they're not called functions, but they behave linearly; we don't use that phrase yet. But this exponential function never gets clearly defined until we get back into Chapters 5 or 6. Nevertheless, that very same problem, which happens to be an investment problem, is recalled in Chapter 3, and it's recalled again in Chapter 4, so the students all know about it—this is one example of a thread that runs all the way through. Aunt Mercedes is going to put $1000 aside for her nephew, and so, by golly, Aunt Mercedes and her nephew come up again in Chapter 3 just briefly, and again in Chapter 4, and finally in Chapter 6.

We begin to consider this function and say, "Gosh, this function is behaving much differently than those others that looked like y=mx+b." We look at them on a graph on our calculator. We can see it's behaving differently, and we say, "Hmm." The text leads us to believe that this has something to do with growth. We might have recognized it was different; now somebody's actually identifying it as being different, and we can call it a growth function.

So some of the things you don't want to push too fast. That's an example of something they're very subtle and very purposeful about throughout here; you would be destroying the integrity of the program to try to talk about exponential functions back in Chapter 2. If you give it a chance to mature, I think it works beautifully.

Probably 75% of the instruction in my classes is teacher-centered. Sometimes I find the teacher-directed approach will get me to my goal in my 40-minute class. Sometimes the desired outcome of a lesson is a little too subtle, and without an awful lot of time for reflection, it can be missed. I find that I can have success with these materials by introducing the activities and then leading the class through portions of the activity before turning it over to them to do some individual work or sometimes some group work while we build the concepts.

We begin to consider this function and say, "Gosh, this function is behaving much differently than those others that looked like y=mx+b."

Supplementing the curriculum

I find I'm supplementing less and less. Initially, I felt the curriculum needed to be juiced up, but the longer I'm teaching it, the more confidence I have in the program and the integrity of the program. I find I'm still supplementing in certain areas with materials that I've pulled together, but I am being much more loyal to the system and letting the system carry itself. From the second chapter of the program on, the program assumes students have a knowledge of integers. If students come to us with a weak background in integers, then we have to step back and bring people up to a level of comfort in order to deal with it. They're certainly not bombarded early on with a lot of need for knowledge of signed numbers, but it is obvious that that's something that was an assumption. Fifty percent of my students come to me without a thorough background in integers, so that obviously has to be picked up.

I've also found in Chapter 5 of the 9th-grade book, where we're doing some equation-solving work, there's not an awful lot of support there for kids who have a weakness in solving equations. That's another place where I have to back out and provide some more background.

I'm not overly critical of this because I've never taught from any single textbook that I didn't find I had to step away from and bring into it something else from my background. With *MATH Connections*, there are wonderful threads that run through the 9th-grade materials, and after having been involved in this for the four years, I see more and more strengths. That's what's pulling me back to the integrity of the program and helping me do less supplementing.

The materials happen to be published in six textbooks, so in theory they are six one-semester books. We don't finish this in three years, so our kids are still in Book 3 while they're in their senior year. It becomes a four-year program in my school, and we include things that they might need later on. In fact, for the kids in *MATH Connections*, we take time in the senior year to teach them some of the things we know they're going to see in college placement tests. We kowtow to that because we want them to be able to stand a fighting chance when they sit down in front of whatever that thing looks like. We still have places in the state that don't allow them to use calculators on their college placement tests, and of course there are many college classrooms that don't allow them to use calculators.

Technology

In my school district, I don't have an awful lot of students who own graphing calculators. Therefore, to make homework assignments that students can do at home, I have to be certain to put together something that they can do without a graphing calculator. Sometimes that requires me to dance around the problem sets that are in the book and create some other problem sets to go along with the concept, so that they can do the work without a graphing calculator. We don't seem to have a hard time of this, but it does certainly prohibit us from having the students do many of the problems that are in the text. It forces us to put together some worksheets where they can be doing things.

In our school district, we don't do an awful lot of things in a computer lab, but I feel we take full advantage of the graphing calculators. The kids come away with a very good knowledge and awareness of the strengths of the technology piece that they've got in their hands.

Student outcomes

Being involved in this curriculum, I've become aware of the fact that there are so many other ways we can be using our mathematics that we never did when I taught a traditional algebra course. The applications make the mathematics course much more interesting and meaningful, which certainly goes an awful long way toward making it much more desirable and increasing student productivity.

We don't have the same kind of failure rates in our *MATH Connections* classes that we have in the traditional programs. This is anecdotal information, but I know from my own classes and from talking with other teachers that our failure rates are much smaller. So that says to me that, well, it must be a little bit more interesting. After the second year we'd been teaching these materials, a parent came to me and wanted to take his student out of the *MATH Connections* program. When I asked him why, he told me his daughter was enjoying math. That was a little contradic-

tory. He said, "She's getting high grades." I said, "Wait a minute. These sound like two outstanding reasons to leave your daughter in here." He said, "Yeah, but math is supposed to be very hard, and if it's just a lot of fun and enjoyment, then obviously there's something wrong; the teacher's not making this rigid enough."

Even though I don't have the seniors myself, I've tried to do comparison testing at a senior level. I find that certainly in the skill areas, the students who've come through the three-and-a-half years of *MATH Connections* are not as strong in the skills as those who have come through a traditional program. Where the *MATH Connections* students certainly do excel is in their ability to demonstrate work with a graph or demonstrate the behavior of functions with a graph, and also an ability to solve problems. I certainly don't think of it as a loss that they can't do the factoring. Symbol manipulation is a little bit weaker and the only time that might present a problem is when they go to colleges or take college placement tests. This is a big item of discussion right now at the secondary level and post-secondary level.

Our SAT scores show definitely that we're not harming students at all. In the state of Connecticut we have this thing called CAPT (Connecticut Academic Performance Test). The CAPT scores of 10th graders show that our *MATH Connections* students score better than the traditional student. I take a look at the students who come into my lower-level *MATH Connections* at the 9th-grade level and I compare their results at the end of the year to their counterparts, the ones who could have opted to come into this course but instead are in a prealgebra course. I am tickled pink by what the students in the *MATH Connections* course know at the end of the year versus the kids who are in a prealgebra course. I know their background in mathematics is so much richer and they can do an awful lot more with their mathematics than can the prealgebra student. I get my satisfaction when I look at their scores in the 10th-grade Connecticut standardized test. I really feel like I'm meeting the needs of that type of student—and this is in the world of algebra for all! These are kids who may never have gotten to Algebra—maybe they would have, but the algebra they're getting in *MATH Connections* is an algebra that will serve them a heck of a lot better.

We have nothing but anecdotal information on college students, and some of it is good and some of it is bad. But when have you ever had every one of your graduates go away to college and get all As and Bs in their math course? So I have to take that with a grain of salt.

I am tickled pink by what the students in the* MATH Connections *course know at the end of the year versus the kids who are in a prealgebra course. I know their background in mathematics is so much richer and they can do an awful lot more with their mathematics than can the prealgebra student.

Professional development

Changes in the world around us create professional development opportunities. Since we have to make certain that we're training all of our students in this area or that area to step out and become much more involved in today's world, the professional development activities that I've been involved in have all merely echoed these changes that we see in society. The professional development activities that I've been involved in have showed us ways to involve students in the activities that are going on. They have gotten us involved in the use of technology and really given me an awareness of teaching strategies.

Staff development is a very integral part of getting involved in this particular program. You wouldn't want to step into this particular program at Year 2 and start teaching with no knowledge at all of what had been taking place in Year 1. Professional development is a very important piece here, not only for learning new strategies, but also just to become aware of the sequencing of topics and how topics are introduced.

When we first began to pilot this, we started off with some teachers who really wanted to do it and they made certain it was successful. Then their enthusiasm spread to some of the other members of the department.

You need the support of your administration. I didn't have total staff support, and I still don't have total staff support. Not all of our teachers are 100 percent in favor of this. When we first began to pilot this, we started off with some teachers who really wanted to do it and they made certain it was successful. Then their enthusiasm spread to some of the other members of the department. The professional development was a very important part, too. We had summer training for two weeks, five days a week, probably six hours a day. Plus during the school year we probably had another 12 to 18 hours on Saturdays. The other very important thing that we did when we started in this program was to make certain that the teachers who were involved in this course had a common planning period, so that they could plan lessons and talk over their problems together.

Now we've got nine or 10 staff members out of 17 who've been through all the training for *MATH Connections*. There are some teachers who still think every student should be striving to take Calculus, and so those few teachers will probably never come on board. But that doesn't make them bad teachers—they're still excellent teachers. My approach has never been one where I go after people with a hammer. We've been able to show steady growth, and have success stories in terms of standardized testing, and so I let that be the mouthpiece.

Changes for teachers

After teaching this same course for four years, I find that the daily preparation doesn't get any shorter. It probably is a little bit less challenging than it was the first year that I was involved in the teaching, but I'm always finding something new. You can spend an awful lot of time in preparation; it's up to you as a teacher how little or how much time you want to spend in grading these materials.

One thing that I like very much about these materials is that each section begins with an outline of the objectives for that section. If you, the teacher, look at that before you begin to read the section, then you know very clearly what the goals are and that helps provide a link for you between what you're reading and what the program is trying to get at, so you can know where the section is going. The way this program is written, each section requires more than a lesson. You will be in a section for multiple days, so either you then pick and choose, or you take a look at the objectives and you say, "Let's see. I can work toward one of these objectives today. I'll build my lesson here, and out of this problem set I may not be able to prepare them for any more than Problem #1, so for tonight's homework assignment I'll assign Problem #1." I'll be in a section maybe three or four days before I accomplish all the objectives; that's another piece that sometimes makes homework assignments a little bit difficult. I think if I were teaching in a block schedule, I would really be able to handle this an awful lot better.

Parents

I recommend that you get the parents very involved right up front. There's always a recruiting thing—for us it's a matter of letting the students choose what course they want. The recruitment is done by meeting with the parents, so we spent an enormous amount of time the first couple of years trying to get the word out about the *MATH Connections* program. We had programs available two and three times a year to meet with the parents. That, we found, was an absolute necessity. Parental concerns, of course, were that this doesn't look like real meaty stuff, that math is painful, and that here you're doing more of this middle-school playing-of-games type of thing. But now we've got some data that we can present to our parents that's very viable and that says, "This is not a wimpy program."

If I've got a parent who says the program is not tough enough, I say, "Alright, in this school we happen to run another track, so take your child out." But I tell them right up front, "Be aware that if you take them out after the first year of *MATH Connections* and they move into a traditional geometry course in the second year, they'll be ahead of their counterparts. But when they get into a traditional Algebra II class two years from now, they're going to be far behind. So you're going to have to make certain that between now and then you get them a tutor to bring them up-to-date on algebraic skills. However, if they stay in our program, by the time they get through our program, they'll have all the math skills that we feel are necessary." I emphasize "that *we* feel are necessary;" I don't say they're going to have all the same math skills that those other kids do. ■

BRYAN MORGAN ▸ MATHEMATICS DEPARTMENT CHAIR

Bryan Morgan is currently the mathematics department chair at Oxford Hills Comprehensive High School in South Paris, Maine, and has acted as the coordinator for *MATH Connections: A Secondary Mathematics Core Curriculum* for the five years the curriculum has been used there. He's been a mathematics teacher for 23 years.

MATH Connections is used at Oxford Hills for freshmen through junior classes, replacing Algebra I, Geometry, and Algebra II for almost 50% of students. Oxford Hills is in a school administrative district in which eight small towns feed into one large middle school and one large high school. The Comprehensive High School includes vocational programs, and has a student population of about 1200. Most students are Caucasian, from rural, relatively poor communities in which farming and logging form the industrial base. The high school facility, however, is new, with state-of-the-art technology available for students.

Goals for students

Our district has always been considered to be on the leading edge of mathematics in the state of Maine. Oxford Hills has a very high-powered mathematics team, for no reason other than a few, very powerful teachers who have run that team. In the 16 years I've been at Oxford Hills, we've tried several different new programs, from the Creative Publications program at one end of the spectrum, to *CORD Applied Mathematics* at the other end, and just about everything in between. Trying different things to prepare our kids has pretty much paid off. Our kids go everywhere for college, including Harvard and Stanford. They come back and say they were as well prepared, if not better prepared, than most of their classmates. Our goal has always been to give them as much mathematics as we possibly can in real-world settings.

Implementation of *MATH Connections*

We initially came upon *MATH Connections* when we were asked to teach it in our inner core and an outer core college preparatory. Traditionally, we've had four levels at Oxford Hills: Level 1, an honors level, was outer core college prep; Level 2 was inner core, traditional college prep; and Levels 3 and 4 were vocational and remedial. Approximately half our students, or a little more, are in our Level 1 and 2 classes.

We brought *MATH Connections* on board to completely replace our inner core Level 2 college preparatory. And we ran the outer core as a dual high-level track, with *MATH Connections* parallel to the high-level track that we've had for awhile. If a student is four-year or two-year college preparatory, they're probably in our *MATH Connections* program. *MATH Connections* primarily replaced a D.C. Heath program, although the D.C. Heath program is still used in our parallel high-level track for freshmen, sophomores, and juniors. Whether they do *MATH Connections* high level or the D.C. Heath program high level, they all arrive in the senior Precalculus Honors class or the senior Advanced Mathematics class.

In the *MATH Connections* sequence, the materials are called Years 1, 2, and 3. Year 1 is primarily traditional Algebra I topics with some probability tossed in, and it starts with statistics as a non-traditional Algebra I topic. The Year 2 books cover primarily geometry topics, although the year ends with matrices as its last topic. And Year 3 follows more traditional Algebra II topics, and includes more rigorous Euclidean and non-Euclidean geometries at the end. Each Year is divided into two semester books: for example, Book 1A and Book 1B. The cost is for one Year, but you get it in two hardcover books. That's what I like to refer to as the wonderful accident that occurred in the program; our inner core Algebra I, for example, does not finish Book 1A and 1B in a year. They get about six chapters out of the eight done. So the next fall, we hand Book 1B out to our sophomores to finish up those last two chapters. Book 1A is handed out to the freshmen; since they're separate books, additional textbooks aren't necessary. The same thing happens sophomore year into junior year. So the kids end up doing every section sequentially through the program.

Mathematics

More traditional mathematics, as teachers might say, appears in the third year of the program. If a teacher picked up a *MATH Connections* Book 1A, and then a

Book 3A, and compared the reading and the topics and the mathematics look of the book, he'd say, "Well, Book 1A kind of soft-pedals it to them, and then by the time they're in Book 3A or 3B, it is very rigorous mathematics." The first two books are designed to get the students hooked. By the time they're juniors and in their third year, it assumes they've become more sophisticated.

For example, let's just talk about the traditional topic of graphing. If you've taught any high school mathematics at all, you know that you pound in slope, you pound intercept, you talk about slant, and kids may be somewhat successful with these concepts their freshman year. But when you ask them at the beginning of their sophomore year, all they remember is that it was hard and they just don't get it. *Connections* takes a whole different approach. Certainly they talk about slope. They talk about families of lines, and parallel lines, and shared intercepts. They soft-pedal that idea to the students, and don't do hundreds of examples, which I had always had my students do. *Connections* lets them practice, but they also try it on the calculator after doing some by hand. Then you can talk about more important things, like "Where do these real data points create a line?" or "How do they create a line?" or "With these two lines, what's the importance of the intersection?" These are real-world, real data-type situations. So can my kids do slope-intercept and linear equations coming out of freshman year? Some of them can. And they can get them on graphing calculators and answer more sophisticated questions about where these lines intersect. By the time they're juniors, the necessity to graph by hand is certainly there, and they're graphing quadratics in a far more traditional sense. But they also still do the quadratics on the graphing calculator. They've now seen graphing for two and a half years, and they're far more comfortable with what type of graphical output should occur when they're given this type of algebraic situation. That is not something that I find traditional. This approach shows them why lines are important, and then makes sure they're able to have that skill by the end of their junior year.

All the topics are developed like that. The program does a great job with statistics. Statistics is soft-pedaled to them early on, and becomes really much harder later on. The program also does an outstanding job in similarity and congruencies in the sophomore year. Probability shows up a couple of times, showing why probability and counting principles are needed, and then a far more formalized treatment is done later on in the series.

Reading and writing in mathematics

MATH Connections books are extremely readable for the students. As a matter of fact, we assign reading as part of their homework almost every night. The books were designed for the students to read, not for the staff to read and then teach. The students themselves say, "Hey, this makes sense." The program develops concepts by connecting to other disciplines and to real-world situations. The kids no longer ask me the question: "How come we have to do this stuff?" It's right there in the reading, and it makes sense to them.

At the beginning of using *MATH Connections*, some students have a hard time understanding the integration of other tasks into mathematics. For instance, when you ask them to read in math class, their eyebrows go up. When you tell them they're going to write paragraph explanations about what they think about something, their first reaction is, "Wait a minute, this isn't mathematics." And that has probably been the greatest hurdle that we work on in their freshman year—that mathematics does not exist in a vacuum, that it's part of all the other skills you're learning as your education goes on.

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It's been hard to convince some veteran teachers, too, that it's necessary to have their students read essays and paragraph explanations as opposed to numeric or symbolic manipulations. The Maine Educational Assessment (MEA) dovetails very easily with the *MATH Connections* program, because all of the mathematics on the test is open-ended questions. I only have to point that out to my teachers and say, "Hey, this is what these kids all have to do in their junior year. We've got to start getting them ready for that right now." But, without a doubt, the hardest thing for students, and sometimes for staff, is to adapt to the writing, the reading, and the talking about mathematics throughout the program. The kids have an easy time adapting to the technology, but getting them to write more than cryptic one- or two-word answers is very difficult.

Impact on student achievement

Our *MATH Connections* students' MEA scores were wonderful, compared to the level of students that I would have compared them to five years ago. The *Connections* kids were better writers than our traditional kids. Their MEA scores certainly were a little bit better on the sections where they had to actually explain what was going on. One of the strengths of the program is that students are exposed to fewer topics than the number of topics in a traditional Algebra I/ Geometry/Algebra II sequence. However, the depth and connectedness of the topics, and their connections to real-world situations, flow so much better in *MATH Connections*. Kids still say, "This is hard," and, "I don't understand," but they don't ask me why they need to learn what they're learning.

Supplementing the curriculum

The teacher's manuals are more than adequate. As a matter of fact, the teacher's commentary that comes with each set of books provides good explanations for each problem and develops each new idea. They're quite useful in that they don't tell you what you have to do; they just plant the seeds in your mind of where the lesson is going. So if you read the teachers' commentaries, preparation is almost done for you.

We've found *MATH Connections* to be lacking in the practice provided for students. The problem sets at the end of each chapter's subsections are erratic, in terms of length and scope of the problems. Some are wonderful, and have plenty for the students to work on; some of them are very limited. So, in the traditional college prep, we supplement the program with worksheets. Since *MATH Connections* is so new, their supplemental worksheet packages had not been available until recently. Supplemental problems have now been printed and are excellent. They are cross-referenced by section. Also, for a few topics in geometry that were left out based on the NCTM *Standards*, we have supplemented worksheets.

Due to block scheduling and more time needed for mathematics, we've actually removed the trig component from the *MATH Connections* high level and the D.C. Heath high level, and require that all our high-level students take a semester of trigonometry separately. Supplementing on the high level is not really necessary, because we get much further into the program in the high level than we do on the traditional level. Any material that's not covered that we think is terribly important is covered in the Precalculus or the Advanced Mathematics their senior year.

Technology

In *MATH Connections*, the TI (Texas Instruments) graphing calculator is very much embedded in the program. We're currently using TI-83s, but TI-82s cer-

tainly are sufficient. Most of the instructions for graphing calculators in the *MATH Connections* materials are geared toward Texas Instruments calculators, but the exercises could be modified to handle any type of graphing calculators. We've used both TIs and computers with the program. I've actually found the TIs more successful, because you can use them, go away to another topic, and then bring them right out again, whereas, when you're in the computer lab, you're in the lab, and the teaching situation is not quite as fluid. For staff who had no background with graphing calculators, we provided training a couple of summers ago.

Classroom quantities of graphing calculators are indispensable. Each of my teachers also has the overhead viewer for the TI-83, so students are able to look up and follow along. Students are assigned a calculator, just like a textbook, except the calculators don't leave the room, so the first thing a kid does when he goes in the room is go to the drawer with the suitcase of calculators and take out his own TI and go to sit with his group. It is recommended, but not required, that our students each purchase one on their own to have at home for homework, because we don't let them bring our sets out of the school.

Professional development for teachers

Professional development is something our district believes in very strongly, so there is a pool of money available for summer training. We had a two-week summer training for Year 1, and then for the next two summers, my colleagues and I took one-week work sessions for Years 2 and 3. We lost two people to retirement in our math department last year, and hired four more, so I provided training for them last summer. I'm qualified to train them. Anyone who has been trained is certainly qualified to retrain other people in their building. I believe that's the way these reform curricula are really going to have to go in, because I know some districts can't afford to send new teachers in for training every time.

One of the things that I criticized during my first exposure to the program, which was a two-week training session for Year 1, was that the program assumed that we didn't know any mathematics. So when I've trained teachers on this, I tell them, "I assume that Algebra I, Geometry, and Algebra II are not a mystery to you. I will show you where the stuff that you already know is in the program, and teach you some of the stuff that's not part of the traditional." Probability is one of those new areas, as well as statistics. Statistics shows up in a couple of places in *MATH Connections* early on, so there's where some retraining needs to be done with teachers.

Supporting teachers

Some of our veteran teachers still have a mindset that what was good 20 years ago is probably still good enough for students. Getting people to try new approaches is the biggest challenge—trying to get them to throw away the worksheets and handouts and tests they've given for 20 years. You have to convince them that we've got a new customer base with new needs. These kids may not need to learn how to factor for six weeks out of the year, but they had better be able to interpret linear equations in a real-world setting, and linear regression and probability and statistics. All of this, which we never taught to our Algebra I students before, is in *MATH Connections*.

One warning is that if you, as an administrator, hand this to your teachers and they are teachers who have been fighting you tooth and nail to continue to do what they've always done, you're going to have to find a way to give it to other people.

It's important, from the beginning, to have your district administration very much involved with the choice of a program like this.

Somebody who reacts very negatively to this program, or any other reform mathematics program, is not going to do a good job on it.

We kept some of our teachers who initially were resistant out of the program. We have 13 math teachers on staff, so we were able to handle the *Connections* program with the people who were really excited. You've got to have people open to change and willing to do what the program asks them to do. Now one of those people who was very resistant is going to take some training from me. He's a 30-year veteran who taught Algebra I for 25 years and he's now ready for *MATH Connections*. But if I'd forced him to teach a *Connections* class four years ago, it would have been a disaster. This way, he has come to me. He said, "Well, I guess I'd like to try some high levels," because the classes that he picked up were lower level, in the *CORD* program. I said, "Well, if you want to take the training and do what we do in the program, I'd love to have you," because he's a competent Algebra I teacher. He's now seen that some of my younger teachers are really excited about teaching the *Connections* material. He's stood back and watched and said, "Yeah, this is okay."

I hear from my teachers that they're now comfortable with the program. I've said to them, "Every time you take on something that's this different, you're a first-year teacher again, so try to remember how long it took you to get to a comfort level." We have a couple of teachers who have just finished their third year of *MATH Connections*. One of these young men said to me, "You know what? I can't wait to start *Connections* again. I really feel I know what they're trying to do now."

Administrative support

Five years ago, when we made the proposal to start *MATH Connections*, our superintendent was very open. She was quite progressive, and pledged her full support, which was quite something for a district with our financial situation. It's important, from the beginning, to have your district administration very much involved with the choice of a program like this.

I hear from administrators that they love what's going on in mathematics. Administrators are great ones for trying to stay at the leading edge, and our administrators are very proud that we're offering this program. They're happy with the feedback they're getting from parents. Our guidance office is happy with what they're hearing from kids who come in. The "I hate math" has certainly diminished among the freshmen students.

It's important to get commitment from your administration for training right up front. This reformed curriculum is something where you can't just walk into the classroom and do an excellent job. Teachers need three to four days of training for a jumping-off period in the first year of the program, and then at least one or two days as they continue through each year of the program. You need to have that type of investment.

Administrative issues

Early on, there certainly were some scheduling issues. The administration agreed that we had to allow, two years in advance, a schedule where the kids who were going to try *Connections* for three years could be kept together. This pool of kids was going to be scheduled first into their mathematics class. That sometimes created problems in other places. If we had implemented the program for all students, of course, that would have been a non-issue.

In terms of kids applying for college, an issue for the guidance department is that transcripts are going to say *MATH Connections* 1, 2 and 3, and some colleges need an explanation of what that means. So we just send out a brief profile with the transcripts of kids who took those *Connections* courses, explaining exactly what it replaced and that it was not a watered-down curriculum by any stretch. Your people in guidance who schedule kids from year to year need to know that, too.

We've heard of some schools that just assumed that the guidance department understood the program, and they showed up in the fall with a *Connections* 1 class full of remedial students. So educating your guidance department right up front as to what this course is designed to replace, or what level or type of student you're piloting the course for, can save a lot of headaches.

Community support

It's also important to involve the community, particularly the people most resistant to change. Parents who were successful in mathematics in high school want their children to have the exact same program that they had, and so your roadblocks are going to come from those members of the community. Bring them in right from the beginning and let them see and read and look over whatever series they have to choose from for reform mathematics. Otherwise, they'll be the ones who will put up the roadblock if they're not informed and have no idea what their children are being put into.

Two of us got the initial training to just pilot the program for the first year at Oxford Hills. We did a blind draw, and had students randomly assigned to our inner core Algebra I, and our outer core Algebra I. Once the kids were assigned, we contacted their parents about *MATH Connections* and said, "This is what we've got for a program, and we'd like your permission to keep your child in it." We had very little backlash since we informed them before the fact. Now that the program has become a norm, we have a parent night every spring for the incoming freshmen. It is extremely well advertised, and very well attended; last spring, 250 kids out of the 300 incoming freshmen had one or both of their parents there. We are very careful to explain that their child is not going to be in a traditional Algebra I textbook. We explain the *Connections* program very clearly to them. And we tell parents of the high-level kids that they have a choice, depending on the strengths of their student. If their student is very verbal and a strong reader, who perhaps hasn't liked mathematics but is still high-level, we explain that the high-level *MATH Connections* is definitely the place for them.

In the fall, there is a newsletter that goes home to the parents, once again reminding them to take a look at the textbook. We explain the technology, so they don't go out and buy something that the kid's not going to find useful in the classroom. We tell them that students have access to a calculator that they can use at school, and if they purchase one for their child, they should keep it at home so it doesn't get lost or broken. Parents have not complained that we haven't kept them informed.

Parents who have taken time to read the textbook are loving it. The only negative parents we still have are the parents who are elitist or highly-educated. I can't yet show them any data that the *MATH Connections* kids are as well prepared for college as I think they are. I can show them that the kids who came through both levels are still accepted at great schools and are still ending up in the top 10 out of 250 kids in their graduating class. But those are the parents I still have to handle with the kid gloves.

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Meeting the needs of different learners

As far as students' different ability levels, *MATH Connections* certainly levels the playing field a bit, depending on the modifications that the staff makes. We kept *Connections* near the upper end of our ability range. There are other schools who've given it to their middle college prep or their vocational prep, and there are one or two schools who have slivered it down right to their "Algebra for Everybody," with the understanding that there's no way, even in four years, they're going to finish the program. If people are wondering about which students the program addresses, I tell them to pick up the book, read it themselves, and compare it to others they're considering. *MATH Connections* certainly can, and is designed to, work at different levels. Is there any one textbook that's perfect for all? I don't think so. I haven't seen it. But this is as good as any—probably better.

At the risk of sounding sexist, the female freshmen seem to be better readers and writers coming in, and *MATH Connections* plays very heavily into those skills. I believe that helps keep females alive in mathematics a little bit longer, while they develop their mathematics skills, which sometimes are behind the boys coming into high school. By the time they're juniors, the field is level, I think, for all of them. And making them read and write in mathematics plays more to what appears to be girls' interests coming into the high school. This past year, I certainly had more girls in my Precalculus Honors class than I did boys. And looking down through the numbers, I expect that trend to continue.

Transitions

Right now, our middle school doesn't have a very current math program, so students are weak in preparation coming into high school. We spend a good part of our time early in the fall of their freshman year getting them away from some habits like not having homework. When they come into *MATH Connections*, it's hard for them to adjust to the work every day, the writing, and other requirements.

On the other end, we have three fourth-year math classes for our seniors: Precalculus Honors, Advanced Mathematics, and Consumer Mathematics. Consumer Mathematics is a senior math course for kids who have done some type of Algebra II through their junior year. At the beginning of my Precalculus class this year, the kids who had come through the more traditional classes were much more sophisticated with, and less intimidated by, the algebraic manipulations. As far as thinking skills, probably the *Connections* kids had a slight edge over the traditional kids. *Connections* kids were more likely to sit back, think, and plan an attack, because *Connections* often gives them problems they have never seen before. What I did get out of my *Connections* kids, that I had a much harder time getting out of the traditional kids, were write-ups of explanations as to why they did things, and what were they thinking.

Is the *MATH Connections* program better than anything else for the high-level kids? No. Is it worse? Absolutely not. It is the one program I would adopt, if I *had* to have one program for algebra. There's no doubt in my mind that I'd go with the *Connections*, because high-level kids can thrive on it, and mid-level kids also thrive on it. Our high-level kids going on to colleges got accepted at the great colleges, still, like they always have. Their SAT scores were equivalent to years past. So we didn't hurt the high-level kids. ■