A TALE OF TWO COUNTRIES AND ONE SCHOOL DISTRICT

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In December 2004, newspapers carried a story about the results of the 2003 Trends in International Mathematics and Science Study (TIMSS)—a test in mathematics and science given to fourth-, eighth- and twelfth-graders throughout the world. As in 1995 and 1999, fourth- and eighth-grade students in Singapore were ranked first in mathematics, beating 39 other countries including Japan, Taiwan, and the U.S. The U.S. has had a poor showing on this exam, despite efforts at reforming math education over the last 15 years—some might say *because* of the reform efforts as have many mathematicians, parents and even (when they are sure no one will tell on them), some teachers.

A few days later on National Public Radio's Science Friday, host Ira Flatow interviewed Robyn Silbey, a math content coach for Maryland's Montgomery County Public Schools. She had been a math coach at College Gardens Elementary School, one of four Rockville, Maryland schools piloting Singapore Mathematics.

Silbey excitedly explained what made the Singapore program so effective, mentioning that test scores on computational math on a nationally normed test for second graders (Comprehensive Test of Basic Skills or CTBS) at College Gardens rose from the 50th and 60th percentiles to the low 90's in the space of four years. Nonetheless, Silbey declared that, despite its pilot program success in Maryland and other states (New Jersey and Massachusetts were mentioned), the use of Singapore Mathematics was not likely to spread further because it did not align with the math standards in many states—including Maryland. Which begged the question: was alignment with state standards more important than increased mathematics achievement? Couldn't it be the state standards that were lacking? While this would have been an interesting course for the interview to take, it didn't.

Ms. Silbey asserted that in the end it didn't really matter what text was used, because the teacher training made the program so successful:

> "I think we certainly could make great strides using any text. … The amount of training, [and] the amount of support [given to mathematics [teachers] in our school during that period would have made us successful no matter what we used."

According to Silbey then, Singapore's success could be embedded in any program that provided teachers sufficient training. With this as explanation, it seemed to make sense to Silbey that schools would drop Singapore at the end of the two year period of pilot implementation. But at the end of the interview she explained that College Gardens elected to keep on using Singapore Math, after the pilot period ended. "We are in our fifth year," she explained. "We may be the only school left out of those four." To which Ira Flatow responded "Hmm".

As did I. If College Gardens was so successful and decided to continue, why wouldn't the other three schools as well? And if the teacher was more important than the text, why did College Gardens elect to keep Singapore's text in place?

Some Googling on the Internet brought up a story published in the local Rockville paper, The Gazette, from 2003 about the Singapore program in Rockville. It was true: three of the four schools dropped the program. The article cited a Montgomery County report that evaluated the success of the program after two years, saying that the four schools using Singapore's method outperformed a control group of four schools that didn't use it. Principals from two of the schools dropping it cited alignment with the state standards as an issue. I was confused again. It didn't align at College Gardens either, but they supplemented it to teach the subject matter lacking in Singapore's texts. Why couldn't the other schools have done that? Plus, the County report gave the program a glowing review. What was I missing? And why did everyone seem OK with this?

WHEN MONEY ISN'T EVERYTHING

John Hoven lives in Montgomery County, Maryland. In 1991, he joined the Gifted and Talented Association (GTA) of Montgomery County, a group devoted to improving math instruction to students in the Montgomery County

He was not happy when he learned that the Montgomery County Public School (MCPS) District had applied for a $6 million grant from the National Science Foundation, Education and Human Resources Division (NSF-EHR) in 1999 to provide teacher development. It wasn't that he was unhappy with the idea of providing professional development to teachers; it was the strings attached to the grant that disturbed him. NSF-HER awarded an "Urban Systemic Grant" to school districts that agreed to train teachers to implement math programs funded by NSF-EHR. The MCPS grant required teacher training to implement a middle school program called Connected Math.

Hoven had heard from a friend whose kids had been through that program that it was not good. Connected Math was one of several "reform math" programs developed by NSF-EHR based on standards developed by the private National Council of Teachers of Mathematics (NCTM). Hoven was not familiar with these standards nor NCTM, but soon would be.

NCTM has a large membership and exerts considerable influence over how math is taught in the United States. Their primary tool is a set of curriculum and evaluation standards first published in 1989 revised in 2000, and most recently issued a set of "Focal Points" which NCTM maintains provides further clarification of the standards, while key newspapers such as the Wall Street Journal and New York Times see the "Focal Points" as a move by NCTM to get "back to basics" and instill the same curricular goals inherent in programs such as Singapore's.

Over the years that NCTM's 1989 and 2000 standards have ruled the educational roost, however, many states have relied on these standards in framing their own. Such standards de-emphasize learning basic skills, relying instead on "strategies for learning" and context-based learning, otherwise known as "real life math".

A dubious educational theory known as "discovery learning" (also known as "inquiry based learning" and "radical constructivism") taught and propagated in education schools across the country informs such standards. The theory holds that only what students discover for themselves is truly learned. Taking it to extremes, teachers and textbooks impart very little information—students are expected to discover key concepts on their own.

NSF-EHR legitimized NCTM's standards and discovery learning, awarding grants for the development of math texts that embodied the NCTM philosophy. One of those programs—the Connected Math Program (CMP)—was developed at Michigan State University in the early 1990's.

The task of convincing MCPS to turn down a $6 million grant for teacher training for CMP seemed insurmountable, but Hoven was convinced that CMP was bad enough that drawing attention to the problem would at least help educate the public about curriculum issues. During the CMP campaign Hoven learned of Singapore Math as a striking counterexample to CMP and he drew the attention of a Montgomery County newspaper.

The newspaper coverage created a public fuss between parents and the MCPS, with its newly-appointed Superintendent, Jerry D. Weast. According to Hoven, to avoid bad publicity almost immediately upon starting his new assignment, Weast found it in his best interests to not pursue the $6 million grant for CMP implementation, and instead opted to pilot the relatively unknown Singapore Math program. MCPS recruited four schools in Rockville, Maryland to pilot the program: Woodfield, Charles H. Drew, College Gardens, and Highland View. Preparation for the pilot began in 1999, training in the summer of 2000, and instruction in 2000–2001. Woodfield dropped the program after the 2001–2002 school year. Charles Drew and Highland View dropped it a year later. College Gardens was the lone school that kept it—at least for a while. They used it all the way through 2005. They announced in fall of 2006 that they would be dropping it.

WHAT IS SINGAPORE MATH? HOW IS IT DIFFERENT THAN U.S. MATH?

Some history

The Singapore math texts are part of the Primary Mathematics curriculum, developed in 1981 by the Curriculum Development Institute of Singapore (CDIS), since renamed the Curriculum Planning & Development Institute of Singapore. The Primary Mathematics Series was first published in 1982, then revised in 1992 to make it a problem solving curriculum. Singapore's math texts have been distributed in the U.S. by a private venture in Oregon, singaporemath.com, formed after the TIMSS results spurred the curiosity of homeschoolers and prominent mathematicians alike.

Interest in Singapore's program has continued, and it has been piloted in a number of schools across the U.S. Shortly after the results of the 2003 TIMSS were published, the U.S. Department of Education released a study conducted under contract by American Institutes for Research (AIR) titled "What the United States Can Learn from Singapore's World-Class Mathematics System (and what Singapore can learn from the United States)". The report compared Singapore's text to various U.S. math programs, including one now in use in Montgomery County, *Everyday Mathematics*, which was developed under a grant from NSF-EHR.

Generally, the AIR report sings the praises of Singapore's program and characterizes the U.S. math texts as weak, citing state standards as a culprit. Textbook publishers cover a wide array of math standards from many states in order to sell their books as widely as possible. However, when texts are not aligned with a state's standards, as was charged in Montgomery County, the texts may not be used.

Less is more

The differences between Singapore's and many U.S. texts is striking. U.S. textbooks are thick and multi-colored; Singapore's are thin and contain only mathematics. They contain no graphics (other than cartoons which pertain to the lesson at hand), no spreadsheet or graphing calculator problems, no social studies problems and no creative writing problems. Students are required to show their mathematical work, not explain in essays how they did the problems.

A math lesson in some U.S. textbooks may address a particular topic like addition of fractions in two pages, skip over to a new topic like measuring angles for two more pages, and then back to fractions. The pages may be filled with colorful figures and in some books I have seen, contain so much information it's hard to know what to read, and harder still to find the problems that the teacher has assigned. By contrast, a lesson in Singapore stays on topic which may take three pages, maybe ten. It may also take the teacher a week to get through the material. The Singapore texts provide problems and questions accompanied by pictures that provide hints about what is going on—there is no narrative explanation. For example, a cartoon figure of a boy or girl may be shown saying "2/5 is 2 out of 5 equal parts of a whole."

Singapore's texts also present material in a sequence that builds throughout the grades rather than the approach used in some US texts in which the same material that is not necessarily mastered is repeated in subsequent grades Concepts and skills are taught to mastery before moving on to the next level. And the next level is properly sequenced to build upon the mastered material. For example, by 6th grade, students are expected to know how to add, subtract and multiply fractions, as well as convert decimals and percents to fractions—no review lessons of these materials are given.

This "building-on" sequence of topics and reliance on mastery is the opposite of many U.S. texts and curricula which rely on a "spiral" approach in which topics are revisited and reviewed at various junctures. *Everyday Mathematics*, for example presents equivalent fractions in the 4th grade, revisits them in the 5th grade and again in the 6th grade. Not all students achieve mastery the first time around. They learn how to multiply fractions in the fifth grade and again in the sixth grade. The explanations for why the multiplication works as it does use different approaches in both grades.

The philosophy of the spiral approach is if they don't get it now, they'll get it later. This assumes, of course, that they remember the cursory treatment from previous years. Students are presented with few problems and little explanation. The program also jumps around from topic to topic, so that interspersed within a unit on fractions, for example, will also be problems on measuring angles and classification of geometric shapes.

Why Singapore students can solve so many hard problems

The most important feature of Singapore's texts is an ingenious problem-solving strategy built into the curriculum. Word problems are for most students the most difficult part of any mathematics course. Singapore's texts help students do this through a technique called "bar modeling" for which students draw a diagram that helps solve the problem. For example, the following problem appears in the Singapore text: "Susan spent 3/10 of her money on a bag. If the bag cost $9, how much money did she have at first?" (See Appendix for discussion of how to use bar modeling to solve this problem.) The bar modeling technique not only provides a powerful method for solving problems, but serves as a link to algebra. Symbolic representation of problems—the mainstay of algebra—emerges as a logical extension of the bar modeling technique.

In many U.S. texts (for example, Houghton Mifflin's *Math* and *Math Expressions*), students are exposed to a variety of techniques to solve problems. Among the techniques are "draw a picture" (which theoretically could include bar modeling, but generally texts do not provide guidance for how to represent problems pictorially, relying instead on students discovering their own way), work backwards, solve a simpler problem, or use a method called "Guess and Check"—trying combinations of numbers until the right numbers are found that satisfy the conditions of the problem. (For example, in the problem above, a Guess and Check strategy is to guess Susan had $60 at first; 3/10 of $60 is $18. Nope, not equal to $9. Try again)

THE U.S. REACTION TO SINGAPORE'S MATH PROGRAM

A Slap in the Face

The success of the Singapore program relies in many ways on the more traditional approaches to math education such as explicit instruction and giving students many problems to solve. This success is a slap in the face to many U.S. math reformers who have been critical of these techniques. While AIR's study states that Singapore texts are strong in treatment of math concepts and "provide rich problem sets that give students many and varied opportunities to apply the concepts they have learned" there is also an underlying murmur in the study that the U.S. is better in some respects than Singapore—a puzzling statement in light of Singapore's number 1 showing on the latest TIMSS results compared to the U.S.' ranking of number 16.

Specifically, the study states that "the U.S. frameworks [standards and curricula] give greater emphasis than Singapore's to developing important 21st century mathematical skills such as representation, reasoning, making connections, and communication. The frameworks and textbooks also place greater emphasis on applied mathematics, including statistics and probability". It also claims that the problems in Singapore's math texts "are not often based on real-world data and information, making the mathematics perhaps less applicable to real life than it should be."

Mathematicians and others knowledgeable in the math wars debates are aware that Singapore's texts do not address statistics, probability and data collection, though in light of Singapore's program as a whole they do not see this as a problem. As such, they view the statements on Singapore lacking in problems based on real-world data as the polemics of adherents of NCTM and its philosophy, and perceive the criticisms to be political window dressing, probably necessary only to get the report published. Nevertheless, the underpinnings of the criticism are worth looking into, since they represent the beliefs of NCTM and education schools on how math should be taught, and tend to color how Singapore's program may be received.

There are generally two types of real-life problems that math reformers seem to believe are effective. One type addresses the messiness of life by asking open ended questions that have multiple correct answers, such as how do you decide how much money to spend on a bike for a bike messenger service you're starting up? Another type in this genre might be to find four numbers whose average is 32, given that one of the numbers is 8. Mathematicians and others opposed to the current slew of math reforms believe that problems like these once in a while are not bad, but a steady diet of them is not. Students' time in class could be better spent learning the math that generalizes to the procedures that are used to solve a variety of messy problems. Furthermore, there is an assumption that without relating math to "real world" situations, students do not see the relevance of math and are bored. In actual fact, however, students by and large like to be able to solve problems. If they can't see how to solve a problem (because they have not been given the adequate prior knowledge and skills by which to solve it), they get frustrated and bored and are then likely to complain "How will I ever use this stuff?"

Which brings us to the second type of problem—one for which students have not received adequate instruction or preparation to solve. Reformers believe such types of problems force students to apply what they know to different situations.

In their online version of "A Parent's Guide to Helping your Child With Today's Math" the National Education Association, extols today's math as "problem-based" with "real world" problems, and provides the following example:

> "A farmer sends his daughter and son out into the barnyard to count the number of chickens and pigs. When they return the son says that he counted 200 legs and the daughter says she counted 70 heads. How many pigs and chickens does the farmer have?"

A discussion then follows about how some students may solve the problem using algebra (if they know Algebra, that is), while others might solve it using Guess and Check. Still others may choose to draw pictures to solve it. NEA admits that some methods might be considered more efficient, but is keen on the fact that the correct answer can be found using multiple methods and that "by allowing students to think flexibly about numbers, we encourage them to 'own' the math forever, instead of 'borrowing' until class is over."

Singapore's texts do not waste students' time by having them invent inefficient strategies. In fact, Singapore's bar modeling technique is a technique that allows students to understand the mathematics of the problem and obtain the correct answer, rather than using trial and error.

Also, introducing problems for which students have not received prior instruction or training is viewed by U.S. math reformers as a door to "discovery" and, ultimately, learning. Singapore differs in this regard by providing the student with the knowledge and skills necessary to solve problems, though the student is expected to apply such knowledge to problems in different contexts and in forms he or she hasn't seen before. Discovery is limited to applying prior knowledge. While US texts may present problems that are above the students' grade level, Singapore's texts present students with problems that are "at" grade level. The result is that Singapore's lower grade students can solve problems that are considered middle-school level in the U.S.[a]

Reformers, however, believe that as long as students see that there are multiple methods to solve a problem, everything is fine even if the methods they use are inefficient. This is generally what reformers mean by "real-life" math. In that regard, it is true that it is missing from Singapore's program—and based on the TIMSS test scores,

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[a] To that end, middle school problems introduced in fourth grade classes were *de rigeur* in my daughter's class which used *Everyday Mathematics (EM)*. Providing students with problems for which they have not been given adequate preparation or prior knowledge is one of several of the discovery techniques used in EM. EM doesn't use a textbook; only a workbook, so there are few to no clues how to solve problems—students must rely on what was discussed in groups in class, and whatever they "discovered". My daughter frequently used "Guess and Check" as did her friend, and as did her friend's mother who is a school teacher and seems to think this is a valid technique. Guess and Check is also a technique listed in the rubrics for scoring "constructed response" questions in some state exams, including Maryland's.

the lack of such problems does not appear to be doing the students any harm.

The NCTM doublethink: It's the teaching, not the text

Despite the failure of Singapore's program to include such "real life" problems, it is still difficult for organizations such as the NCTM and education schools ignore the fact that Singapore's students' are outperforming all nations participating in TIMSS – and that U.S. students are trailing by a large margin. Cathy Seeley, a former president of NCTM, got around this when the 2003 TIMSS scores were released by stating that "the more we learn about what is being done in the Asian Rim countries, the more it appears that mathematics is not taught in the same way in which we have traditionally taught mathematics in this country." Thus, Seeley states that what is working in Asian countries is they are not teaching math in the traditional way—which is to say if NCTM standards were followed more in the U.S. we would be doing better. And by inference, Singapore must be following NCTM's standards.

David Klein, a mathematician at California State University at Northridge and long a critic of the math reforms brought about by NCTM and their followers, finds all of this a rationalization. "Math reformers assume that math education is bad in the U.S. because the NCTM reforms were not properly implemented nor understood by teachers. They never consider the possibility that the NCTM standards themselves are one of the causes of poor math education in this country."

A SHOCK TO THE SYSTEM

The pilot of Singapore Math in the four Rockville, Maryland schools was to run for two years, starting in school year 2000–2001. The introduction of the Singapore Math program to the four pilot schools in Montgomery County was a shock to the system. The selection of the pilots and general preparation began in 1999 and the textbooks and other teaching materials arrived at the four schools in late spring of 2000, giving teachers three months to prepare for the upcoming fall semester with Singapore Math. The four schools were in a panic.

But Singapore's materials were different from anything they had seen. The teacher's manuals Singapore's Primary Mathematics series provide very little guidance on how to teach a particular lesson. They are written for teachers in Singapore who have a deeper understanding of mathematics and are trained in how to teach from such texts. For example, a teacher's manual contains the following guidance on the multiplication of fractions lesson: "Fold a paper into halves, and then into quarters. Lead the students to see that 3/4 of 1/2 is 3/8." Teachers in Singapore can conduct such a lesson, but U.S. teachers do not have the same experience and need more explicit instruction. Not all the teacher training materials used in Singapore were made available to Montgomery County.

The MCPS, then, provided the bulk of the training to the teachers in the four schools.

Two of the schools, College Gardens and Highland View, also hired math specialists (coaches) to help in getting the program off the ground and in coordinating the training within the schools. At College Gardens, the math coach was Robyn Silbey —the person interviewed on National Public Radio. After a few rough starts, Silbey told me, the MCPS established monthly sessions to ensure that everyone was on the same page using a supplementary program called "Lenses on Learning". Apart from the training, however, she attributes the success at College Gardens to the huge effort (in which she played a large role) the school made. (She has written about this experience, and her writing appears in Appendix C of the AIR report).

Taking on a program like Singapore's meant going against what many teachers believed math education to be about. Teachers generally felt that Singapore's text did not contain "real-world" activities nor promote "discovery learning". Despite these reactions, teachers in the four schools generally came to accept the program. According to AIR's study, overall the teachers in the schools liked the new textbooks, and 75 percent indicated that MCPS was moving in the right direction through their introduction.

There was still reluctance for some, like Silbey, to fully credit the strength of the textbook material, though. Silbey, in her interview with Ira Flatow, had echoed the same "teacher not text" argument that Cathy Seeley had made, stating that it was the knowledge and skill of the teacher that made the difference rather than the text or curriculum a school may use. In talking with me, Silbey explained that the main reason for the MCPS piloting of Singapore's program was to obtain research on exemplary math curricula around the world.

> "You take the best of the best and incorporate it into your teaching. It's the person in front of the room asking good questions and getting them involved in discussions, developing higher order thinking skills," she said. "I've seen teachers with the best textbooks do a poor job, but good teachers with no texts do a superb job."

She did not mention that the strategies may come from or be motivated by the books. For example, the AIR study reports a teacher at one of the schools saying "Having to explain Singapore mathematics made me understand that I never really understand the mathematics I was teaching."

Sherry Liebes, the former principal of College Gardens, disagreed with the "teacher not text" argument. She was pleased with the results of Singapore's program and felt strongly that "it teaches students to be thinkers." When I asked her about the role of the textbook versus the teacher, she at first said that obviously teacher training is important, but added that Singapore's text provides a structured curriculum and "it's one less thing for teachers to worry about". She was struck by the difference between Singapore and U.S. texts. "In the U.S. math is spiraled without much depth added," she said.

In Silbey and Liebes' view then, the training needed to run the program was dictated by the Singapore texts themselves and required a school-wide effort to understand how it linked together. According to Liebes, at College Gardens they phased in Singapore's program rather than requiring all grades to use it all at the same time. By doing it this

way, students in later grades (4th and 5th) were not at a disadvantage for not having received important lessons in the Singapore 2nd and 3rd grade books. Generally, the Singapore books are about a grade ahead of US students by grade 4, and in some cases, even by grade 3. The phase-in approach, with emphasis on curriculum that College Gardens undertook turned out to be critical to its success, since Singapore's program is a very carefully arranged sequence of concepts and techniques, each proceeding logically from earlier material. The other schools in the pilot did not do it that way and implemented all grades all at once.

Scott Baldridge, a mathematician from Indiana University, provides professional training to teachers implementing the Singapore program. He is co-author, with Tom Parker, a mathematician from Michigan State University, of a book on the subject. Baldridge points out that Singapore's teacher manuals do not explain with sufficient clarity how carefully constructed the Primary Mathematics Series is. In his experience, if teachers are teaching multiple years of this series they seem to eventually self-realize the curriculum sequence and use it to their advantage because they begin to see the whole picture. Some teachers get it on their own, he says, but many, especially the ones that teach only one year, need professional development to see how the curriculum interacts with the students over several years.

College Gardens and Highland View were, inadvertently, the only schools that followed Baldridge's recommendation in seeking professional development, though the facilitators did not have prior experience with Singapore Math. Nevertheless, these two schools performed the best on the Comprehensive Tests of Basic Skills (CTBS) in mathematics.

The role and beliefs of the principal cannot be overstated. College Gardens continued using the program after the other schools dropped it. After Liebes left, they continued using but in the fall of 2006 they announced that they will be discontinuing it. That said, and notwithstanding the beliefs of some that Singapore's texts are a minor consideration, it is evident that the teachers, facilitators and principals of the four schools worked very hard to make the program work. My hat is off to them.

What were the results?

The results of a program are typically evaluated by looking at test scores. College Gardens shows a dramatic increase for both second and fourth grades in the nationally normed Comprehensive Tests of Basic Skills (CTBS). In the second grade, scores for the math computation portion of the CTBS increased from the 58th percentile in 2000 to the 90th in 2001 and 2002, the 94th in 2003. For fourth grade, scores increased from the 71st percentile in 2000 to the 87th in 2001 and 2002, before decreasing to the 80th in 2003. Of the other three schools, Highland View also showed consistent, though not as substantial, increases. The remaining two schools did not exhibit large changes and in some cases, scores decreased in the second year of the program. Interestingly, the two schools showing the biggest improvement used math facilitators in helping teachers with the program. While the math computation scores at College Gardens show a dramatic

improvement for both 2nd and 4th grades, in "general math" there is no discernible pattern; Highland View and Woodfield had either no change or a decrease in scores in general math.

Another source of information, however, came in the form of a two-year study conducted by the MCPS Office of Shared Accountability. This office conducted evaluations for 2001 and 2002 and tested the students in the four pilots with two control groups of four schools each. Control Group A had additional teacher training, including in effective instructional strategies, while Control Group B had none. The studies showed that the four pilot schools not only outperformed both control groups, but progressed through the curriculum at an accelerated pace compared with their peers in the control schools. According to the study, this acceleration helped the Singapore Math students in higher level mathematics placements in middle school.

Admittedly, the study was flawed in that there was no baseline for the four schools using Singapore Math. That is, there was no information on how the four pilot schools did compared to the two control groups *prior* to the inception of Singapore Math. Notwithstanding this flaw, the results of the MCPS report were left to stand. Despite the unchallenged positive result, however, there was no celebration of the news at MCPS. As one parent put it, "These results should have had administrators hopping up and down, shouting to the world that they've found a way to improve mathematics achievement among students of every category." Instead, the MCPS ended funding for the program after the second year. If schools wished to continue, they had to pay for the materials out of their own budget. Another issue cited was that Singapore's program did not align with Maryland state standards.

Misalignment with state standards

The Maryland standards for mathematics were in place before the Singapore Math pilot began. The standards included data analysis, statistics, and probability that Singapore's texts did not address. In 2001, however (during the second half of the first year of the pilot), Superintendent Weast commissioned a consulting firm to rewrite the entire MCPS K-8 curriculum to align it with the Maryland standards. By state law, each school district had authority over its own curriculum. Although required to administer state tests, school districts were not required to align their curriculum with the state standards. They could choose to aim for "world-class standards" instead, which John Hoven says at one time was one of the stated goals of the MCPS Long Range Plan. But the Plan was revised by MCPS to accommodate state standards instead—a move, say some, designed to lower Montgomery County's standards.

Jerry Dancis, a University of Maryland math professor, objected both to Maryland's state standards and the district curriculum revisions they engendered. He and John Hoven wrote a letter petitioning the State Board of Education to revise the state standards to be world class. The petition stated that a key goal of such a revision would be districts aligning their mathematics curricula with the most rigorous international and state content standards available, such as Singapore's and California's. He collected 50

signatures of prominent mathematicians.

Dancis presented the petition at a monthly meeting of the Maryland State Board of Education in March 2002. Donna Watts, of the Maryland State Department of Education, characterized the petition signers as college professors who were only interested in future college students majoring in engineering and math (thus effectively shutting off discussion from anyone who might have believed that the goal of education is to provide students with options rather than closing any doors).

MCPS' revised curriculum was implemented in fall 2001, during the second year of the Singapore pilot. With the introduction of the revised curriculum it became obvious what the Singapore curriculum lacked, even though the standards requiring statistics had been in place prior to that. Hoven argues that the statistics component of Maryland's standards is junk mathematics. "It's just vocabulary; students learn what range, maximum, minimum, mean, median and mode are, plot graphs, and not much beyond that. It's easily supplemented." Supplementing the statistics topic is what the pilot schools did.

A lesson in short-term thinking

Even with the so-called misalignment problem, the MCPS report showed good results for the Singapore program compared with other schools. Nonetheless, from Superintendent Weast's standpoint, there were no compelling reasons to stick with the program. Besides, the prospect of continued success with the Singapore program would create a Catch-22 for Weast, since it would discredit his strategy of aligning the curriculum to Maryland's standards. I.e., if the schools using Singapore are doing well despite misalignment, why push for it?

At the same time, since the MCPS report did not indicate that Singapore Math was a failure, Weast didn't look bad for having piloted it.

To explore these issues further, I thought it might be instructional to hear from Weast himself, so I compiled a list of questions that I sent to his office. I wanted to hear Weast's thoughts on why misalignment with the Maryland standards was a problem given that the program could be easily supplemented, and what would his position be if any of the schools that dropped the program decided to take it up again.

I heard back from the MCPS information officer who told me "I understand that you spoke to our math folks so that should be sufficient for your story."

What the math folks had to say

Leah Quinn is the Math Supervisor for MCPS, and one of the "math folks" to whom the information officer was probably referring. We talked a bit about Singapore Math and I explored the misalignment issue. She surprised me by saying that not only was statistics coverage missing in Singapore's program but "Singapore Math has little focus on computation with common fractions." The program relies on the metric system, she said, so there were no "real life" problems that illustrated how fractions are used in non-decimal measurement situations. Singapore's treatment of fractions, she said, is rooted in the decimal system and there is not a large focus on other types of fractions such as 1/8, 1/6 and so on.

Ms. Quinn was correct that the schools had used texts that predated the release of the U.S. edition which includes inch-pound measures. The non-U.S. editions of Singapore's texts, however, include many non-decimal fractions and in non-measurement problems, contrary to Ms. Quinn's claims. For example, there are roughly 600 fraction problems in the first semester of fourth grade alone. Quinn's implication that the metric system used in the books eliminates the need for common fractions is not true. There are problems using 1/3 and 1/8 of a liter, or meter, or kilogram, for example. One problem from the fourth grade text illustrates that the Singapore text treats common fractions within the metric system: "Mrs. Ruiz bought 4/5 kg of beef. She cooked ¾ of it for lunch. How much beef did she cook?" The answer is expected in terms of a common, not a decimal, fraction. And a problem from the fifth grade text illustrates that "measurement" with fractions goes beyond the metric system units of length, weight and volume, as well as illustrating the complexity and richness of Singapore's treatment of fractions: "3/7 of the apples in a box are red apples. The rest are green apples. There are 24 green apples. How many apples are there altogether?"

Changing the subject, I asked her why College Gardens continued the program while the other schools dropped it. Were the other schools not allowed to continue? She wasn't part of the decision making process, she said, and added that such decisions would have been made with the principal and community superintendent, based on the test scores.

Nevertheless, Quinn was definitely a key part of the program, considering that the U.S. Department of Education sponsored a trip for her to Singapore. She was sent in 2001, met with Ministry of Education officials, and observed how the math program was implemented there. What she picked up from the trip she did not say. What she did say was that MCPS has incorporated the elements of Singapore's program into its curriculum. "Like the bar diagram method of problem solving?" I asked. "Definitely," she said. They are put in "noteboxes" as instructional guides for teachers. Instructional guides are publications distributed to teachers that provide lesson ideas and which accompany their math texts. Noteboxes illustrate specific concepts, and may appear on a page in the guide, enclosed in a box like a sidebar in a magazine article. Bar modeling is illustrated in such a box in the belief that a single explanation in a reference manual is enough to get across to anyone the nuances and techniques of teaching with this method.

In talking with the principals of the schools, the reasons for dropping Singapore were a combination of misalignment and cost of the texts.

On the subject of budget, Joanne Steckler principal of Highland View (now retired) said quite plainly that being required to purchase their own materials was what caused them to finally drop it. “For one year we did purchase our own Singapore materials. But most of the materials are consumable and quite pricey and it was becoming a hardship. We did not want other curricula areas to suffer because of lack of funds to purchase materials, so we gave up Singapore Math.”

Shawn Miller, principal of the Woodfield School cited both the cost of the texts and misalignment with the standards. Once the MCPS stopped funding purchase of the texts, they felt it was better to have their funding put into the new series—*Everyday Mathematics*—“which was better aligned with the state curriculum,” and one which he felt was more rigorous.

Educational bureaucracy and the threat to social equity

Hoven feels that the MCPS administrators—not the schools—were hostile to Singapore Math from the start and that most principals will do what they think their superiors want them to do. Hoven attributes educational bureaucracy functioning to two critical decision-makers:

1. The superintendent, whose primary motivation is to look good in the eyes of people who are not professional educators; and
2. The administrators, whose primary motivation is to pursue the mission they learned in education school and to look good in the eyes of their professional peers.

The schools, in Hoven’s view, are the victims of these decision makers. They respond to their incentives and disincentives. And although these two decision makers have different motivations, Hoven believes they lead to the same result: the lowest standards they can get away with.

> “I believe the schools wanted it to succeed,” Hoven says. “It was the central office math administrators who wanted it to fail”.

In Hoven’s view, the NCTM standards play to the ideals of the educational bureaucracy which has historically been moved by compassion for low achievers. Thus some programs including but certainly not limited to Everyday Math narrow the achievement gap at the expense of reduced learning and mastery. Programs that emphasize mastery, like Singapore Math, may raise performance overall, but the gap may widen. Therefore, Singapore is a threat to the goal of social equity because of the perception that the slower learners may not catch on. The result is that school then becomes a place that emphasizes engaging activities that don't require prior skills or knowledge, rather than what the Singapore program does: building skills and knowledge grade by grade.

> “I think the teachers did work very hard,” Hoven says. “It was forced on them

> and they didn't like it at first. Not to mention that a lot of the hard work was imposed on them by unreasonable actions of MCPS administrators."

Montgomery County is not alone. Elizabeth Carson, who heads NYC HOLD has led a battle for years to get an adequate math education in New York City, and rid the schools of programs like Everyday Mathematics. "The tragedy for our children and our nation is education school theory and the NCTM-guided programs and standards," she says. Those programs "trusted and quickly embraced by school administrators, in district after district, and state after state, across our nation—are in fact egregiously lacking in essential K-12 mathematics content and rigor. The US reforms bear no resemblance to the programs and standards of the highest achieving nations."

With the schools dropping Singapore's program in Montgomery County, John Hoven resigned in 2005 from the Gifted and Talented Association. "I had stopped believing I could make a difference," Hoven says. "I felt it was time for someone else to try."

In the meantime, the decline in the numbers of U.S. trained scientists and engineers, compared to the increasing numbers of those trained in Asian countries, has not gone unnoticed. In this year's State of the Union address, President George Bush stated, "We need to encourage children to take more math and science, and make sure those courses are rigorous enough to compete with other nations." He proposed "to train 70,000 high school teachers, to lead advanced-placement courses in math and science … bring 30,000 math and science professionals to teach in classrooms … and give early help to students who struggle with math, so they have a better chance at good, high-wage jobs."

A few months later, President Bush created the National Mathematics Advisory Panel (NMAP) to advise the President and the Secretary of Education on the best use of scientifically based research to advance the teaching and learning of mathematics. The panel includes several people who have actively fought against the "fuzzy math" trend.

While the goal of bolstering high school math is a laudable one, the success of high school students in math depends on what they've learned in the lower grades. If those foundations are weak, the addition of Advanced Placement (AP) courses in math and science in high schools will prove to be a weak enhancement. Unfortunately, changing the way math is taught in the lower grades appears to threaten an educational philosophy and method that is not only pervasive in our schools, but leaves us with not much to show for academic excellence. Perhaps one of the first things the newly appointed NMAP can point out is that students do not learn what they have not been taught. That statement doesn't even require scientifically based research to prove.

*Barry Garelick is an analyst for the federal government and lives in Fairfax County, Virginia. He is a national advisor to NYC HOLD, an education advocacy organization that addresses mathematics education in schools throughout the United States.

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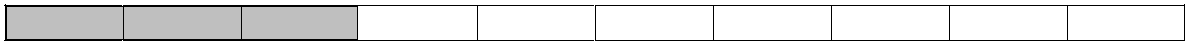
APPENDIX

The bar modelling technique prepares the way for more developed discussion on a topic and leads into algebra. For example, the following problem taken from a 4th grade Singapore math workbook, is one that is easily solved using bar modelling, without knowledge of division by fractions, or algebraic equations:

> "Susan spent 3/10 of her money on a bag. If the bag cost $9, how much money did she have at first?"

Knowledge of division by fractions would yield a solution in the form of $9 divided by 3/10. But this problem is presented before students know how to divide by fractions.

With bar modelling students set up the problem as follows:



----------$9----------

Students first recognize what they know and what they don't know. They know that 3/10 of the money she started with equals $9. They don't know how much money she started with, but obviously the money left over plus what she spent is 10 tenths. Since 3/10 of her money equals $9, then looking at the diagram students see that since each of the three tenths totalling $9 is equal, each tenth is $9 divided by 3, or $3 per tenth. Since there are10 tenths in all, the money Susan started with is 10 x $3, or $30.

In this way, students see what information they do know, what they don't know, and how to use what they are given to find the solution to the problem