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Guest Editorial…

Ruminations on the Final Report of the National Mathematics Panel

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On March 13, 2008, The Final Report of the National Mathematics Advisory Panel (NMAP, 2008) was released. President George W. Bush had established the Panel and charged its members to use the best available scientific research to give advice on how to improve mathematics education. The Panel "found no research or insufficient research relating to a great many matters of concern in educational policy and practice" (p. xv). The Panel acknowledged that, in light of the perceived lack of high-quality research, instructional practice should also be informed by "the best professional judgment and experience of accomplished classroom teachers" (p. xiv).

My goal in this article is to illustrate some of the points made in The Final Report using my own experiences. I have taught in a two-year public college, a four-year public college, a four-year private college, a public high school, and a public middle school. Much of my career was devoted to helping students in developmental studies or learning support (remedial) mathematics classes. Also much of my effort has been and still is in working with pre-service and in-service teachers. During the 2005-2006 academic year, I took a leave of absence from teaching pre-service and in-service teachers in order to teach seventh-grade mathematics. Many, but not all, of the illustrations used in this article will refer to the experiences in the middle school (hereinafter referred to as SMS). The illustrations represent principles I especially would like to convey to pre-service teachers.

The main findings and recommendations of the Panel are organized into seven areas: Curricular Content, Learning Processes, Teachers and Teacher Education, Instructional Practices, Instructional Materials, Assessment, and Research Policies and Mechanisms. This article does not attempt to address all of these, nor does it claim to elevate the status of the principles illustrated here above other principles. The reader will want to read the entire Final Report to be well-informed about what it has to say to mathematics educators.

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Disparities in Mathematics Achievement Related to Race and Income

The first chapter of The Final Report provides background for the President's charge to the National Mathematics Advisory Panel. It cites the United States' performance on international tests and the vast demand for remediation in mathematics in college. It goes on to address disparities in achievement:

> Moreover, there are large, persistent disparities in mathematics achievement related to race and income—disparities that are not only devastating for individuals and families but also project poorly for the nation's future, given the youthfulness and growth rates of the largest minority populations. (NMAP, 2008, pp. 4–5)

The National Assessment of Educational Progress clearly demonstrates the disparity in performance on mathematics test items when students are categorized by race or income (U. S. Department of Education, 1990/2007). In addition, the state of Georgia provides another source of information about disparity in performance through the results of the state's high-stakes Criterion-Referenced Competency Test (CRCT) (The Governor's Office of Student Achievement, 2007). Student performance on the CRCT for a school, a system, or the entire state is summarized by showing. what percent of students are placed in each of three categories: Does Not Meet, Meets, and Exceeds. During the 2005-2006 school year, for example, 19% of the seventh-graders in Georgia did not meet expectations; however 28% of the black seventh-

Table 1

Mathematics Criterion-Referenced Competency Test Data

Group	Does Not Meet Standards	Meets Standards	Exceeds Standards
2005 – 2006 7th Grade Georgia	19%	58%	23%
2005 – 2006 Black 7th Grade Georgia	28%	61%	10%
2005 – 2006 White 7th Grade Georgia	11%	57%	32%
2005 – 2006 7th Grade Georgia Economically Disadvantaged	28%	62%	11%
2005 – 2006 7th Grade Georgia Not Economically Disadvantaged	11%	55%	34%
2006 – 2007 SMS 7th Grade	34%	58%	7%
2005 – 2006 SMS 7th Grade	26%	56%	18%
2004 – 2005 SMS 7th Grade	32%	61%	7%
2006 – 2007 SMS Black 7th Grade	32%	64%	4%
2005 – 2006 SMS Black 7th Grade	20%	64%	16%
2004 – 2005 SMS Black 7th Grade	32%	61%	6%
2006 – 2007 SMS 7th Grade Economically Disadvantaged	34%	56%	10%
2005 – 2006 SMS 7th Grade Economically Disadvantaged	27%	58%	15%
2004 – 2005 SMS 7th Grade Economically Disadvantaged	38%	56%	7%
2006 – 2007 SMS 7th Grade Not Economically Disadvantaged	36%	62%	2%
2005 – 2006 SMS 7th Grade Not Economically Disadvantaged	23%	50%	27%
2004 – 2005 SMS 7th Grade Not Economically Disadvantaged	21%	71%	8%

graders did not meet expectations (See Table 1). Twenty-three percent of the seventh-graders exceeded expectations, whereas 32% of white seventh-graders exceeded expectations, compared to 10% of black seventh-graders exceeding expectations.

The state's statistics for economically disadvantaged students were practically identical to statistics for black seventh-graders for the 2005–2006 school year. SMS is a school with approximately 20% black students and 75% students who qualify for free or reduced lunch. Students with an identified disability comprise 16% of the school. With this demographic information, it is interesting to note some of the test results for the school. For example, 18% of the seventh-graders at SMS exceeded expectations on the 2006 CRCT, compared to 7% the previous year. Of the black seventh-graders in 2006 at SMS, 16% exceeded expectations, up from 6% of the seventh-graders in 2005. Only 20% of the black seventh-graders did not meet expectations on the 2006 CRCT, down from 32% the previous year. As for the economically disadvantaged, the percent not meeting expectations declined from 38% in 2005 to 27% in 2006. During the same time period the percent of economically disadvantaged students exceeding expectations rose from 7% to 15%. Of those students in seventh-grade at SMS who were not economically disadvantaged, 27% exceeded expectations in 2006, compared to 8% in 2005 and 2% in 2007.

In presenting this data I emphasize that teachers should not be content with examining data that only looks at an overall pass rate on tests such as CRCT; they must question why disparities exist and then work for equitable instruction. There should be high expectations and the opportunity for all students to learn mathematics. A primary reason for my teaching a year at SMS was to reach the disadvantaged students. I am encouraged by the results as indicated by CRCT data, both looking at patterns across years at SMS, as well as looking at SMS compared to state data.

Conceptual Understanding, Procedural Fluency, and Automatic Recall of Facts

The report of the Panel provides more emphasis on the hierarchical nature of mathematics than has been evident in the past two decades. It calls for a "focused, coherent progression" (NMAP, 2008, p. xvi) and for avoiding any approach that "continually revisits topics year after year without closure" (p. xvi). The Georgia Performance Standards (Georgia State Department of Education, 2008) also operate on the assumption that students have mastered content from previous grade levels.

Students' lack of prerequisite skills is a major challenge to teachers. For example, the Algebra I teachers surveyed by the Panel sent a strong message that a source of concern for them was their students' inability to work with fractions (NMAP, 2008, p. 9). The National Mathematics Advisory Panel saw this particular difficulty as "a major obstacle to further progress in mathematics, including algebra" (p. xix). However, the difficulty with fractions is persistent long after students have completed four years of mathematics in high school, including calculus for some students. Recently I gave a pre-assessment on fractions to a class of pre-service teachers. This assessment consisted of six questions: simplifying a fraction, adding a mixed number and fraction, subtracting two mixed numbers, multiplying two fractions, multiplying two mixed numbers, and dividing two mixed numbers. For this recent class of pre-service teachers, the mean and median number of questions correct was three. In addition to numerous errors in the whole number arithmetic (e.g. 20 – 6 = 4), several students treated multiplication of fractions as a proportion and tried to work with cross-products.

The knowledge about fractions is an example that illustrates complex issues related to teaching. Will a focused curriculum result in no longer having a need to revisit fractions? Do the Algebra I teachers revisit fractions? Do calculus teachers revisit fractions? If so, how is the re-teaching different from the initial exposure? The fact that pre-service teachers have made it through four years of high school mathematics and still cannot perform operations on rational numbers shows that the problem is much wider than the concerns of Algebra I teachers. Ma (1999) provided the classic example of lack of conceptual knowledge about fractions in her data on the inability of U. S. elementary teachers to give an example of an application that called for division of fractions. Clearly the procedural knowledge about fractions of pre-service teachers is also lacking.

Actually many of these pre-service teachers have always been tracked with the students who excel, even though there are significant gaps in their knowledge. As a result of tracking, they have not encountered students who experience real difficulties with mathematics. To illustrate the reality of the gaps in the younger students' mathematical understanding, I will relate some of my seventh-graders' lack of prerequisites.

One of our first new topics in my seventh-grade class was signed numbers. As students began to work on some exercises I had given them, I went around observing their work. As I stood over one girl, I saw many tally marks, and at first I had the impression she was just doodling. However, as I lingered over her, I saw that she was doing 92 + -17, by making 92 tally marks and crossing out 17 of them. At a later date, I asked the same girl to identify which digit in a numeral I had written was in a certain place value; her response was an incorrect one, representing a digit on the opposite side of the decimal point from the correct answer. I should probably add that the response was not just a matter of whether the word had a –ths ending. These are only a couple of examples of the missing pre-requisites that surfaced for a student entering the seventh grade.

Another girl was having difficulty with signed numbers. One strategy I use in making sense out of addition of integers is to relate it to a "common-sense example." In her case I tried to get her to find -5 + 1 by asking her if I owed her $5 and paid back $1, how much would I still owe her? It was her third attempt to answer the question before she gave a correct response. With a different student who was learning-disabled, I attempted to do a task analysis to enable him to multiply decimals. However, I met with extreme difficulty when he did not seem to be able to count the number of decimal places to the right of the decimal. As I pointed to the digits to the right of the decimal to get him to count them, he shook his head as if he did not know what I was asking. With both this student and the girl attempting to answer -5 + 1, there was certainly a lack of self-efficacy in addition to the lack of prerequisites. Later in the year when the class was on a totally different topic, I saw a smile come over the girl's face as she exclaimed, "That's easy!" and realized she could expect herself to be able to do mathematics.

On the other hand, some of the more capable students with prerequisite skills did not exhibit conceptual understanding. For example, even though he knew most of his multiplication facts and could perform the standard algorithm for multiplication, one boy resorted to finding the product of 92 x 8 by repeated addition (92 + 92 + 92 + 92 + 92 + 92 + 92 + 92). One of the questions teachers must struggle with is how much time and energy to spend on procedural learning. Several years ago I had read a question that haunted me: Is the goal of school mathematics to make children as good as a $5 calculator? I firmly believe that conceptual understanding is important and that calculators can free people up to concentrate on the steps of how to solve a problem. However, my seventh-grade experience made me feel terrible when I thought about the fact that my students were not as capable of doing arithmetic as a $5 calculator. In addition to not knowing basic facts, they did not possess conceptual understandings, such as when to use multiplication and where to place a decimal point in a product.

Some students with disabilities are allowed to use calculators as an accommodation. In dealing with some mathematical content, the calculator does not provide the desired efficiency. When students do not know multiplication facts, divisibility rules are not really shortcuts. When divisibility is not recognized, trying to find the prime factorization of a number can become even more challenging. Similarly, simplifying fractions is an arduous task.

The National Council of Teachers of Mathematics (NCTM, 1989), in its first standards document, called for calculators to be available to all students at all times (p. 8). The revision a decade later (NCTM, 2000) clarified that there are times calculators are to be put away (pp. 32–33). Use of calculators in prior grades was a concern expressed by Algebra I teachers surveyed by the National Math Panel (2008). The Panel's response was to caution "that to the degree that calculators impede the development of automaticity, fluency in computation will be adversely affected" (p. 50). The Panel summarized the balance among conceptual understanding, computational fluency, and problem-solving skills: "Debates regarding the relative importance of these aspects of mathematical knowledge are misguided. These capabilities are mutually supportive, each facilitating learning of the others" (p. xix).

Affective and Motivational Factors

The Panel (2008) cited empirical evidence that children's focus can be shifted from their innate ability to their engagement in mathematics learning, and that this will improve their meeting the learning outcomes (p. xx). The Panel called for educators to help students and parents understand this relationship between effort and performance.

These points are certainly important, but the assumption is being made that all parents and students value education. At a parent-teacher conference close to the beginning of the year, one mother of a seventh-grader told me she did not believe in teaching "that higher math." The "higher math" consisted of negative numbers and percents. Checkbooks and shopping were not sufficient examples to convince her otherwise. About two weeks before the end of the year, the step-father of another student told me that a high-school diploma was just a piece of paper. He had dropped out at age 15 and worked in the textile mill ever since and, in his mind, had never needed a formal education.

Note that a distinction must be made between recognizing different views towards education and blaming the home environment/parents' lack of value toward education for low academic performance. As pointed out by DeCastro-Ambrosetti and Cho (2005), as long as a rift between home and school exists, communication between parents and teachers will continue to be strained and hindered.

Other affective aspects that must be considered in working with students include situations that make it hard to focus on schoolwork. Emotional difficulties students might experience include depression, abuse, and separation from family members. Because we as educators believe that education is the ticket out of bad situations, the stress of daily dealing with these kinds of problems can sap one's strength and make the value of adding mixed numbers, for example, seem questionable. Of the algebra teachers participating in the survey commissioned by the National Mathematics Advisory Panel (2008, p. 9), 62% rated working with unmotivated students as the single most challenging aspect of teaching Algebra I successfully.

Individual Students' Achievement Gains and Instructional Practices

Although the difficulties of emotional baggage and lack of prerequisites pose challenges for high achievement in mathematics, the gains of individual students can be staggering. In addition to the analysis of how SMS seventh-graders performed on CRCT as a whole, by race, and by economic status, I scrutinized the performance of my students individually by checking records to determine their past scores.

CRCT scores were reported for individuals for the years cited in this article on a scale that sets 300 as the minimum score to earn "meets expectations." Scores of at least 350 were categorized as "exceeding expectations." The minimum mathematics score of one of the students I had in the seventh grade had been 255 the previous year. The minimum for 2006 was 15 points higher at 270. The highest score for 2006 was 375, whereas the highest score for those students in 2005 had been 359. One of the students who exceeded expectations posted a 49-point increase from his score the previous year. Other students had increases of 26 points and 34 points over their 2005 scores. The average gain for students in my inclusion class was 14 points per student. The National Mathematics Advisory Panel (2008) acknowledges "little is known from existing high-quality research about what effective teachers do to generate greater gains in student learning" (p. xxi). I present the data from my seventh-graders' CRCT scores in order to encourage teachers to study measures of achievement of individuals and to identify promising practices.

Teacher-education programs may espouse what constitutes best practice to the point that a pre-service teacher might accept that training without question.

Similarly, teachers may find themselves in systems where they are required to use a certain curriculum and follow a certain format, be that a scripted lesson or a work period with closing presentations by students. Teachers need to have the freedom to use their professional judgment and to develop and assess effective techniques.

Assessment

The Panel (2008) does state that teachers' regular use of formative assessment improves students' learning (p. xxiii). Pre-service teachers may particularly need help in learning to "kid-watch," informal assessment, to assess their students' learning. Often pre-service teachers are tied up in the content or the activity of a lesson and cannot identify students who have misconceptions. I offer some examples of the informal assessment that took place in my seventh-grade mathematics classes.

At the beginning of the year, I asked the students to make a poster about their favorite number. I told them that my favorite number was eight. I showed them several ways of performing arithmetic operations to get a result of eight. They were to show on their posters many ways to write their chosen number. Interestingly, only one student wrote an equation involving a fraction. One student was able to show that she understood she could make an infinite number of equations to get her number by continuing to increase the minuend and subtrahend by one each time.

Another beginning of the year activity I chose was to give the students old calendars, have them choose a 3 x 3 square on it, and add the nine numbers in the square. I hoped to use the activity to show them how I could tell in advance what the sum would be, using n to represent the middle number, finding algebraic expressions for each of the other numbers in terms of n, and finding that the sum would always be 9n. However, I realized that even though understanding variables was a sixth-grade Georgia Performance Standard (Georgia Department of Education, 2007), the students were not comfortable with using a variable in the calendar context. Moreover, I realized that perhaps only one or two in a class of sixteen students could accurately add these nine numbers!

I found myself using few formal assessments throughout the year of teaching seventh grade. Assessment was something that took place every day, and it was used to inform instruction. So to new teachers I repeat the rhyme: "A teacher on her feet is worth two in her seat." The teacher should not just be maintaining discipline and monitoring seatwork, but should be questioning and probing for students' understanding.

Conclusion

The Final Report of the National Mathematics Advisory Panel (2008) is the most recent document published that offers advice on how to improve mathematics education. The Panel's task was arduous, involving reviewing 16,000 research publications. It is somewhat disheartening to know that, in the Panel's assessment, there is insufficient high-quality research to draw many conclusions. Nevertheless, mathematics educators will continue to search for meaning from their own experiences and to conduct research.

Qualitative research, which seemed to take root in light of the fact that in education it is too difficult to control all the variables, will be overshadowed once again by quantitative research with experimental and control groups. Perhaps the Panel could take on the role of setting up experimental designs and hypotheses and then recruiting researchers to carry out the studies. Just as mathematics specialists may be needed in elementary schools rather than trying to increase the mathematical proficiency of all teachers, the research specialists are needed to insure that investigations will meet the tests to be considered rigorous.

Meanwhile, the pendulum will swing on many facets of mathematics education, but teachers will continue to go to classrooms every day and offer stability and safety to all. They will provide their students with multiple opportunities to succeed one class period at a time, but have high-stakes assessments like the CRCT looming over them every day. They will do their best to show the relevance of mathematics. They will want their students to understand *why*, even when the students do not care *why*. They will keep searching for the answers for not only how to best teach *mathematics*, but also how to best teach *students*.

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