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Middle School Math Teaching and How It Harms Our Children

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I wondered why American children learn so little arithmetic in middle school (grades 7 and 8). I also wondered why most American children need to be retaught arithmetic in Grade 9 and why many colleges even teach arithmetic (under the name of developmental mathematics). (In most countries, children complete their study of arithmetic in grade 7). As my children went through middle school, I watched as their self-confidence to do mathematics eroded. This forced me to monitor what was happening in their classes. I analyzed this from two perspectives: as a parent and as a college teacher of mathematics. I am writing this report to share my findings with other parents so that they may understand what is happening to their children.

THE CALLING-OUT-THE-ANSWERS METHOD OF INSTRUCTION

One professor of mathematics education has noted: “[Mathematics in middle schools is] delivered through an instructional model comprising call out the answers to the homework, work a few examples, assign seatwork. There is very little communication of ideas about mathematics among students or between teacher and students, either asked for or allowed in many classrooms. Kids leave thinking at the door of the classroom and go on automatic pilot.” This teaching style is conducive to students collecting misconceptions about math as well as turning children into math haters. Also, when a child has a wrong answer he/she will not have a clue as to the errors or how to correct them (after merely hearing the answers called out).

COOKBOOK TYPE INSTRUCTION

It is standard for math textbooks and K-8th grade teachers to provide students with cookbook type directions of what to do in math. It is rare for students to be assigned problems that they have not been programmed to do. It is rare for textbooks and K-8th grade teachers to provide the students with understanding-based explanations which tell the whys and the

wherefores of mathematics.

With skill-based instructional methods, the students spend large amounts of time mindlessly doing dull exercises in a rote manner. Doing calculations in a skill-based manner divorced from understanding results in students memorizing an excessive number of formulas which **are easily confused and easily forgotten over the summer**. Also, skill-based instruction leaves the students stymied when confronted with a problem that is only mildly different from the ones they have been programmed to do. This is one reason for low math SAT scores.

Providing students with understanding-based explanations of mathematics is not a common teaching technique. “**Explaining mathematics to students**” was **not** included in my local school system’s Spring 1990 proposed list for “The [Math] teacher’s role in discourse.” The natural result is that while the students may develop some proficiency in math skills, they do not gain any understanding of the mathematics. This results in students collecting all sorts of misconceptions about mathematics and making a wide range of mistakes while doing calculations. This, in turn, results in less success in high school math classes. Remedying these misconceptions is difficult.

A major reason for the low achievement in mathematics in U.S. schools is that the mathematics curriculum is overly repetitive and fragmented.¹ In France addition of fractions is first taught in 8th grade; here it is taught in 4th, 5th, 6th, 7th and 8th grades. At the end of 8th grade, more French students know how to add fractions than American students.

INEFFICIENT USE OF CLASS TIME

Eighth grade math teachers use (on average) only 40% of class time for teaching, (that is for the teacher talking, class discussions and students working in groups). The other 60% of class time is used for tests

and seatwork. Increasing teaching time to 60% would enable students to progress through both the 7th grade and half of the 8th grade syllabi in a single year, thereby increasing the pupils' sense of accomplishment and reducing the level of boredom.²

SEATWORK IS USUALLY GLORIFIED BUSYWORK

Interesting and/or challenging seatwork is wonderful, and children need to do some exercises to learn anything, but unfortunately, in many classes most seatwork is just glorified busywork. Children learn very little while doing a large number of arithmetic exercises, and it even has a major counterproductive effect of turning misconceptions into "bad" habits. (This has been observed by Owen and Sweller (JRME Vol. 20) and by Dr. Kastner of U.MD. (at Towson) (retired) resp.)

TEACHING TO MASTERY

One of my children's teachers actually allocated more than half the class time to tests and quizzes. She would give a test on Monday, then a retest on Wednesday for those who did poorly on Monday's test, and a second retest on Friday for those who did poorly on Wednesday's test. The pupils who were not taking the retests were relegated to the boredom of busywork. This class took three quarters of the year to cover the first half of the syllabus. The excuses--lack of time and "teaching to mastery." The considerable amount of time squandered on retesting could have been allocated to teaching the untaught part of the syllabus. Parents, who insist that their children receive good grades, encourage and even coerce teachers to waste class time on retesting until the scores are high. This occurred at a middle school which received *national honors* from President Bush as a "School of Excellence." It is also a school of "choice" as it has a special "magnet" program. *All the parents* of children in this special program had specifically *chosen* it for their child even though it meant sacrificing their child's neighborhood friendships by bussing them to this non-neighborhood school.

That the overemphasis on testing sets students up to do poorly when they enter college was noted in discussions by faculty members from 10 departments of my university, together with high school teachers and college freshmen. The main conclusion was: **"The overemphasis on testing, skill development and fact content, etc. [in schools] seems to have inhibited [stu-**

dent] interest in learning, motivation, ability to work with and enjoy ideas, use creativity, and attain satisfaction from an educational experience."

STUDENT WORK IS RARELY CORRECTED

Of course, all tests are graded, but teachers rarely specify just what the errors are or even if the errors are of a mathematical or a stylistic nature. Usually neither students nor teachers analyze patterns of errors. The natural consequence of not dealing with students' errors and misconceptions is that students do not learn from their mistakes, and they **repeat the same mistakes** on later tests. **"Correcting students' work"** was **not** on my local school system's Spring 1990 proposed list of "Instructional Interventions."

ALL-OR-NOTHING GRADING

The subject was factoring; the problems were to simplify several mathematical formulas. A child factored the numerator correctly, factored the denominator correctly, canceled like factors on top and bottom correctly, and then made the arithmetic error of $2 \times 3 = 8$; score 0 out of 20 points because the final answer is wrong. On this test of factoring, the child factored *everything correctly*, clearly demonstrating full knowledge of factoring, and "earned" the flunking grade of 55%. (At my university, where we do not use all-or-nothing grading, the score on this *same* test paper would have been in the 90's.) On other tests, mathematically *correct* work received *no* credit when the form of the child's answer was different from the one in the teachers' manual. Sometimes this is the result of teacher rigidity; sometimes it is the result of the teacher's lack of mathematical knowledge, and of course, it takes several times as long to read test papers as it does to merely glance at the final answers.

Considering that teachers are already overworked, where could the extra time be found for correcting student work instead of merely doing all-or-nothing grading?

REDUCE TESTING

How to solve three problems with one command from the principal: Reduce testing time by half.

- This would free up one half of the time the teacher now spends on grading papers so that it could be used for correcting the work as well.
- This would free up much class time which could result in the students making significantly more

progress in a school year.

- This would result in the students becoming less test-oriented and suffering less test anxiety.

This reform of reducing testing time by half in middle school math classes could be instituted today at **no cost** to the taxpayers. I am aware that this reform is antithetical to middle school culture, and insisting on it is an infringement of the principal's prerogative of providing educational leadership as he/she wishes.

MISLEADING GRADING

All-or-nothing grading underevaluates a child's knowledge. Giving busywork the same importance as tests *often* produces grades that do *not* reflect learning. When a child receives a low grade and/or is told to repeat a course, the child, his/her parents and guidance counselors do not know whether the child has not learned the math or whether this is a consequence of all-or-nothing grading and/or the child not doing the busywork. In fact, these were the reasons my child's math grades were so low that the child was placed on the list to repeat the course even though, *according* to the teacher, the child had indeed learned all the mathematics! This occurred at the school of "excellence" and "choice" that my children had the privilege of attending. On the other side, many students receive good grades without having learned the math. Last year, 10% of the freshmen at my university were ordered to take two giant steps backwards and retake Algebra 1 in spite of the fact that they received grades of A or B in Algebra 2 in high school.

THE MIDDLE SCHOOL *TEACHERS'* KNOWLEDGE OF MATHEMATICS MAY BE *CRUCIAL* TO YOUR CHILD'S SUCCESS IN HIGH SCHOOL MATHEMATICS

In California a survey by Ms. K. Culler revealed that among Grade 8 Algebra 1 students who were taught by a teacher who did **not** have a math major or minor in college, only 20% did well in Algebra 2 two years later. Students who were lucky enough to have a Grade 8 Algebra 1 teacher who *did* have a math major or minor in college did much better in Algebra 2. It is rare that a middle school principal checks whether or not a teacher is *fully* qualified to teach math before hiring or assigning a class.

THESE INSTRUCTIONAL STRATEGIES ARE BORING

At my children's school, it was not uncommon for students to pass notes via flying paper airplanes. I did

my parental duty by asking my child why she was passing notes instead of listening to the teacher. The answer: "If I can learn everything by listening with one ear, why do I need to use both ears? In science class I don't pass notes because I need to listen with both ears." Most students will pay close attention to an interesting lesson, but boring lessons force students to "tune out." Passing notes is a harmless way for children to protect themselves from boredom; less polite students act out their boredom in disruptive manners. There was so much gossiping that the principal found it necessary to admonish the students to do less talking and socializing in class. When a student walks into a class he/she should sit down quietly and start working with no discussions in between. The principal did *not* say that there would be any reduction in the level of boredom at school. Basically, he was blaming the victims.

How common is middle school boredom? Clinical psychologist Dr. Robert Weigl and social worker Abby Sternberg's survey of causes of **stress** at Hayfield Secondary School in Alexandria, Virginia, (a suburb of Washington D.C.) found that 50% or more of the pupils in each grade from grade 7 to grade 12 were under **stress due to the boredom** of school work. Also, 40-50% of the pupils were under **stress due to too much school work**, especially too much *busy* work that took up too much time. School work being too hard was *not* a common source of stress. Of course, boredom results in students losing interest in school work.

Predictably, the instructional strategies described above do not work for middle school math even though the syllabus's level of sophistication is quite low, even by standards for 13-year-olds. This is why so many students need to be retaught arithmetic under a pseudonym like "General or Developmental Math" in grade 9. They will **not** prepare students for the MD State Dept. of Education's new grade 8 math test.

THE BOTTOM LINE

These methods of instruction do not result in much learning of mathematics, even by the best students. In Sept. 1990 the select students entering the special Science/Tech program at Eleanor Roosevelt High School (in a suburb of Washington D.C.) included 178 students who had all successfully completed Algebra

1 in middle school. Only 20% of these select students had learned enough algebra to score 70 or higher (out of 100) on the simple Algebra 1 Criterion Reference Test.

The types of instruction I have described are a *waste* of the taxpayers' money and of the teachers' and pupils' time. Worse yet, they are **counterproductive** since the main results are

- pupils with many misconceptions about arithmetic. The misconceptions become bad habits, difficult to remedy. This results in the pupils making many mistakes while studying algebra in high school.
- pupils with greatly reduced self-confidence
- pupils who hate math (many students leave elementary school liking math, but they quickly become math haters in middle school) and
- pupils (even bright pupils), their parents and guidance counselors who incorrectly believe that the pupils are poor learners of mathematics. The natural consequence of this is that the students choose non-challenging mathematics courses in high school, thereby limiting their career choices.

When I consulted other professors of mathematics and math education, I learned that the educational practices described here are very common in middle schools. Lowering class sizes, giving more tax money to schools, adding more days to the school year and school-based management (the current panaceas for improvement) will *not* address any of the problems mentioned in this report. In fact, school-based management may help to *perpetuate* these practices by reducing the pressure for improvement from a central administration.

Partially in reaction to the ineffectiveness of the types of instruction described above, the National Council of Teachers of Mathematics (NCTM) is recommending a new national math curriculum (outline) called the "Standards." These NCTM Standards call for a major deemphasis on skill-based learning and rote practice together with major emphasis on students gaining knowledge and understanding.

In 1987, in reaction to the ineffectiveness of math instruction, the MD State Dept. of Education was wise enough to issue the following:

SIDEBAR

The problem was to simplify the fraction

$$\left(\frac{9a^3b}{7-x}\right)\left(\frac{2x-14}{3ab^7}\right)$$

The child factored the numerator correctly and cancelled correctly. The child's answer was

$$\frac{-2(3a^2)}{b^6}$$

which is equal to

$$\frac{-6a^2}{b^6}$$

the answer demanded by the teacher. Initially, the teacher scored this question as zero points out of 25. On the remaining 3 questions full credit (75 points) was given. Thus, for this mathematically perfect test paper, the initial total score was 75% (C).

Of course the child had no idea as to why no credit was given for the work on problem #1. The following day, the child asked the teacher to point out the error. The teacher responded by giving partial credit of only 5 points out of 25 for this problem, raising the total score to 80%.

This occurred at a school of "**choice**" as it has a special "magnet" program. *The parents* (of the 200+ students in the "magnet" program) had *chosen* this program for their child even though this meant sacrificing their child's neighborhood friendships by having him/her bussed to this non-neighborhood school. When I informed the principal that this type of grading was occurring, as well as many other things listed in this report, he chose not to respond. Then I informed the assistant superintendent of schools, (the principal's boss) and also presented her with several test papers with mathematically correct answers marked wrong; her response was "Thank you for sharing this with us." The test papers were not regraded. The principal and the assistant superintendent had more important things to deal with; that year the school received *national honors* from President Bush as a "school of excellence," and the principal was promoted to be principal of a high school.

OFFICIAL GOALS FOR MATH INSTRUCTION³
(Emphasis added.)

Goal #1 is that students will “develop an appreciation of and a **positive attitude toward mathematics.**”

Goal #2 is that students will develop an **understanding of mathematics**: concepts, properties and processes.

Goal #3 is that students will “acquire mathematical facts and skills.”

Goal #4 is that students will “develop the ability to express and interpret mathematical ideas and relationships.”

Goal #5 is that students will “develop the **mathematical reasoning ability** required in problem solving and decision-making situations.”

Goal #6 is that students will develop the ability “to apply mathematics in personal, societal, technologi-

cal, scientific and career settings.”

Unfortunately, it is the rare middle school which has the expertise to make a serious effort to implement these goals.

NOTES

¹ This is one of the major conclusions of *The Underachieving Curriculum* by Curtis C. McKnight et al, a national report on the Second International Mathematics Study sponsored by the International Association for the Evaluation of Educational Achievement (1987). This report is the most thorough analysis of mathematics education in American schools. The name of the report comes from the report's conclusion that the mathematics curriculum in American schools is an **underachieving curriculum**.

² The data on how teachers use class time is listed in *The Underachieving Curriculum*.

³ These goals are presented and discussed in the wonderful booklet: *Mathematics — A Maryland Curricular Framework*. This framework was developed by June M. Danaher, specialist in mathematics, Maryland State Dept. of Education. The superintendents of the county public school systems in Maryland have signed off on these goals.

Changing the Subject, Or, Would You Hire a Good Clarinet Teacher to Teach Your Child The Violin?

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Roughly, the first (milder) half of this article appeared in the Forum column of the Prince George's Extra Section of the Washington Post, April 21, 1999, Page 4. Parts enclosed in [] were not included.

Sarah McKinney-Ludd, a language arts teacher in Prince George's County, said her assignment to teach a middle school math class “robbed kids of a year of education. I stayed up every night for 180 days,” she said. “I didn't sleep. I can't sleep because you have to stay ahead of the kids...It is emotionally bankrupting.” (Linda Perlstein's front-page article, The Washington Post, Feb. 15, 1999).

Not assigning music teachers to teach math or vice versa is a no-brainer, except to too many school administrators and the school board.

Hospitals do not let a lung specialist fix broken bones on a slippery, icy day when there is an overload of patients with broken bones. Building contractors do not have plumbers and electricians filling in for the others' jobs. Parents never hire a good clarinet teacher to teach a child the violin.

That the head of a middle school math department be a certified math teacher is another no-brainer, except