A Critical Observation and Discussion of a Common Educational Practice: Timed Multiplication Tests

An Honors Thesis (HONRS 499)

by

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In our society, individuals first encounter mathematics at a very young age. In lower elementary school, we begin with addition and subtraction. We then progress to multiplication. As we venture through our studies, we form opinions about the subjects. The Third International Mathematics and Science Study (TIMSS) revealed that by the twelfth grade, American students are greatly lagging in the areas of mathematics and science compared to other industrialized nations (Pursuing Excellence). Thus, as a society, we must concern ourselves with improving our international standing. An appropriate location to begin observing mathematics is at the elementary level. A common practice at this level is the timed multiplication test. One must decide whether timed multiplication tests actually test the desired concept in a valid manner without gender biases.

In order to explore the impact of timed multiplication tests, an informal study of 18 third and fourth grade students and three teachers in a small Midwestern school was conducted. The sample of students was 44% male and 56% female. Almost 40% of the students reported that math was their least favorite subject. A majority of that 40% were female. Webster's New World Dictionary defines multiplication as "the process of finding the quantity obtained by repeating a specified quantity a specified number of times" (Guralnik 395). However, different ways of explaining multiplication exist. One way is simply as repeated addition, for example, three times four is simply four, plus four, plus four, which equals twelve. Eighty-three percent of the students described multiplication in this manner, including the students who described multiplication using

groups. For the previous example, "3 × 4" could be explained as "three groups of four items," still 12. The remaining 17% of the students could not answer the question, "What is multiplication?" The teachers had similar definitions of multiplication. One teacher explained, "multiplication is shortened addition." Another expressed that, "multiplication is a way for students, or people in general, to find the answer to a problem where multiple groups of what you have are needed." The last said, "it is repeated addition, a pattern of addition."

All three teachers use some version of a timed test. However, they all begin by using manipulatives such as counters and groups to introduce the concept. They then explained that eventually, they "use timed tests to check computational skills." One teacher asks the students to answer the question, "What is multiplication?" using words or pictures and the students' written responses are kept in individual portfolios. She then uses timed tests "just for fun." Another teacher asks the students to individually explain multiplication as if she does not "know anything." She then tests the students individually by showing them flash cards and tapping her foot as a timer.

The teachers attempted to test in "the least painful way," as one teacher explained. Another clarified that, "I try not to make them (timed multiplication tests) traumatic. I try to make it positive." However, when discussing timed tests, 56% of the students offered negative responses about timed tests, for example, they felt "nervous" or "scared". Of the 28% that offered positive comments, they were all related to performance. For example, one student said, "It makes me feel good when I get my personal best." However, he

followed with, "Some people could feel down like they don't know their multiplication." His use of "like" could express that the other student might "know his multiplication," but just did poorly on the test and therefore believes he is inadequate.

When asked, "What is 9 times 8?" only 83% of the students were able to correctly reply 72. When asked "Why?", 28% could only offer that 72 was the answer that they had memorized. Another 28% were able to show a "trick" that works with the nines. For example, if one places his hands in front of him, he has ten fingers. If he wants to multiply seven times nine, he puts down his seventh finger. He will be left with six fingers to the left and three to the right. Thus, 7 times 9 is 63. Using a nine was a poor choice for the study because the students knew at least four such "tricks." Seventeen percent of the students answered the question based on groups and some even used upper-level thinking based on the distributive property, $a(b+c)=ab+ac$. One student explained that, "9 times 8 equals 72 because 9 times 9 equals 81 and 81 minus 9 is 72." When asked what 8 times 9 equals, all of the students replied that 8 times 9 equals 9 times 8, the commutative property of multiplication. However, when asked "Why?", 87% of the students were only able to offer answers like "because it's the same question basically, just backward" or the numbers are just "switched around." Thirteen percent could not offer an answer. One student did express higher-level thinking when he explained, "72 can be 9 groups of 8 or 8 groups of 9."

Since little purpose exists in possessing a skill if one does not know when to properly use it, another important issue to address is "When is multiplication used?" A vast variety of answers exist since people frequently use the concept. One third of the students could not supply a single occasion in which multiplication is used and another 17% could only respond with in "math" (the subject in school). Most of the students who answered math were unable to come up with any other places in which multiplication is used. Of those that did answer a specific example, two thirds could only offer instances related to stores, specifically grocery stores. The students were able to offer few practical uses of the concept. When asked why they personally need to know how to multiply, 50% of the responses pertained to the students' futures, for example, "in college." Some even simply stated, "for my future." As the National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics (NCTM Standards) explains,

> the mathematics curriculum should include concepts of addition, subtraction, multiplication, and division of whole numbers so that students can develop meaning for the operations by modeling and discussing a rich variety of problem situations; relate the mathematical language and symbolism of operations to problem situations and informal language; [and] recognize that a wide variety of problem situations can be represented by a single operation. (NCTM 41)

According to the study, these students were vastly lagging in this Standard 7 for grades K-4.

Anxiety can stifle some students' motivation and interest. Most students would agree that they worry about grades and that grades are motivators. However, most educators believe that the most important goal should be whether or not the student understood the concept and was then able to apply it, rather than grades. Although ideally, grades would reflect this goal. One student responded that when taking timed tests, "I feel nervous that I won't get enough done." This student has veered even further from the goal of understanding the concept by not simply desiring to "get a good grade" but "get enough done." Timed tests can take the student's main focus away from the concept of multiplication. The student has placed an emphasis on the wrong goal.

The NCTM Standards state, "the purpose of computations is to solve problems" (NCTM 44). The purpose of learning the basic multiplication facts must not be overlooked. The Standards continue to explain that a vast majority of computations in the real world today are done by calculators or computers. When people do find themselves computing, estimations are often sufficient. "The importance of teaching children a variety of ways to compute" is discussed in Standard 8 (NCTM 44). "Mental computation and estimation offer exciting opportunities for making computations more dynamic and for developing insights into number relationships" (NCTM 45). The one student in the study that offered the explanation based on the distributive property was quite insightful. He will be able to apply his knowledge of the basic facts for multiplying larger numbers. For example, when he must multiply 3 times 98, he should experience

less trouble understanding that the answer, 294, can easily be found by subtracting 6 from 300. Based again on the distributive property, 3 times 98 equals 3 times (100-2). The frequent use of different methods offers children the opportunity to develop more realistic views of computations and allows the flexibility necessary to choose computing methods. "Both mental computation and estimations should be ongoing emphases that are integrated throughout all computational work" (NCTM 45). Traditional timed multiplication tests have little to do with meeting these goals.

In addition to considering what timed multiplication tests actually test, one must also examine them for gender biases. The so-called "gender-gap" in mathematics is a very controversial current issue which has sparked much media attention. Steven Goldberg published an article in 1989 explaining that, on average, women score 60 points less than men on the SAT. This fact promoted the same author to claim, "SAT scores accurately reflect male superiority in math" (21). While this statement angers many educated people for a variety of reasons, the fact that women have consistently scored below men on standardized mathematics tests should raise some concern. While huge career opportunities are open for women, "some critical choices are being ignored -- choices to venture into courses of study and employment in mathematics and sciences" (Contemporary Issues 5). Society is increasingly growing dependent on mathematics. However, women, as well as African Americans, Hispanics, Native Americans, and people with disabilities, are hugely underrepresented in such fields at every level. These fields of study and careers in

general are also very well paying. This lack of representation may relate to the significantly lower average income of women than men. While economic issues alone justify further investigation, "Women may also fail to achieve sufficient mathematical and scientific understanding to become fully knowledgeable citizens" (Contemporary Issues 5).

Two of the teachers interviewed in the study did not notice any gender differences in the performance of the students in mathematics. However, one of the teachers said that usually she does notice a difference, but she has not this year. She said, "the boys pick it (multiplication) up just like that."

"The issue of providing equitable educational opportunities for all students is as important as any issue educators face today" (Miller, Mitchell, and Van Ausdall 437). One must observe some of the occurrences in a typical classroom:

> Girls talk significantly less than boys do in class. In elementary and secondary school, they are eight times less likely to call out comments. When they do, they are often reminded to raise their hands while similar behavior by boys is accepted. (Sadker, et al 17)

This quote suggests that impulsive behavior by boys is rewarded. However, the same behavior by girls is corrected. "Substantial evidence exists that from birth females are conditioned by society to more closely follow the rules than males, to be neater, and to be more careful in their approach to problems than males" (Miller, Mitchell, and Van Ausdall 438). Timed tests are almost purely impulsive.

When the time constraint is added, one must question if we are testing in a way that encourages one sex to succeed and one to fail since one has obviously been better prepared for the testing method. "If equitable opportunities are provided little will be accomplished if the way achievement is measured is biased and distorts the accomplishments of females and other groups" (Miller, Mitchell, and Van Ausdall 437).

A study by Shelagh Gallagher and Edward Johnson was titled "The Effect of Time Limits on Performances of Mental Rotations by Gifted Adolescents." This study observed the skill of mental rotation by using a testing procedure that allowed students to complete the test after the time limit. They concluded that "the results of this study demonstrate that the reason for differences in spatial ability may have more to do with speed of performance than ability" (41). A study conducted by L. Diane Miller, Charles I. Mitchell, and Marilyn Van Ausdall similarly suggests that by eliminating the time limit on SAT-type tests, the vast gap between male and female scores was lessened, while it still existed. These two studies expressed that the large gender-gap in scores may have more to do with time restraints than ability. Gallagher and Johnson furthermore warned that "the research also serves as a reminder that many of the tests we use to identify gifted students or otherwise judge the achievements of students value speed of performance over reflective and careful thinking processes" (19).

Since timed multiplication tests seemed to favor certain students, the study expected to observe a correlation between those

that had positive feelings toward timed tests and the students that preferred to simply submit an assignment without the opportunity to make revisions. However, no such correlation was found. The study observed the preference of all of the students, even those with negative attitudes towards timed tests, to simply submit a finished assignment. The results of this study merit further scientific investigation in order to draw broad conclusions. Some of the factors that could have influenced the results are too small a sample size, unscientific methods, vast parental involvement with the school and children, and school size.

The consequences of purely memorizing multiplication facts as opposed to understanding the concept of multiplication extend far beyond elementary school. Most adults would agree that the basic facts that were difficult to remember in elementary school are still difficult to recall. Rajendra Jutagir, Ph.D. explains, "With aging comes a normal decline in intelligence and specific functions such as memory" (45). Members of our society must be able to multiply. The quote implies that for many, recalling even a simple multiplication fact can become increasingly difficult as we age. Thus, we need to understand the concept of multiplication in order to figure out the answer to a multiplication fact when memory fails us.

One basic algebra teacher at Ball State University was "amazed" by the number of students who could not make basic computations. Several of her students were able to successfully complete the algebra on a test, but had multiplied six times seven incorrectly. At first, the problem may appear to lie in memorizing the basic facts. However,

based on the information that memory loss occurs with aging and some of her students had learned to multiply almost 20 years ago, she concluded that what the students actually needed was a way to find the correct answer when memory fails. For example, they could actually draw six groups of seven and count the numbers or add seven, six times. In order to be able to complete one of these manual methods of multiplication, the students would need to possess a thorough understanding of the concept of multiplication. The Mathematics Model Curriculum Guide for California explains, if a student "does not have an understanding of the concept represented by a symbol, no amount of practice working with that symbol will help to develop that concept" (CDSE 10). Students deserve to have an understanding of the concept of multiplication so that they can use if later in their lives.

Mathematics is a vast subject. Multiplication is the first concept students must address that is not completely concrete. True mathematics is not about speed. Fermat's Last Theorem, originally written in the margin of Pierre de Fermat's Arithmetica text in the 1600's, was not proved until this decade, over 300 years latter. Most mathematicians would place the values of truth and validity above speed. While time is important, time frames are relevant to the situation. David Clarke, Doug Clarke and Charles Lovitt explain that "It is through our assessment that we communicate most clearly to students which activities and learning outcomes we value" (118). Thus, the fact that one student from the study replied, "Time is

REALLY important in math" should not be surprising. However, no student deserves to believe this fallacy about mathematics.

While students do need to be able to recite a given multiplication fact on demand, many reasons exist to question the use of timed tests. Timed tests severely emphasize rote memorization while de-emphasizing a true understanding of the concept. "The thought that teachers may be systematically biased against certain groups of students is not a pleasant one to contemplate, but teachers must be aware that the items chosen for evaluations may be highly prejudiced" (Miller, Mitchell, and Van Ausdall 437). Timed tests also help to create negative feelings, misconceptions, and anxiety about mathematics. Additionally, they could promote the gender differences seen in upper-level mathematics. By using timed tests as a means of evaluation, we are deceiving our students by de-emphasizing their future means of "remembering" and understanding basic facts and estimations and possibly creating a gender difference, negative feelings toward the subject of mathematics, and finally a vast misconception about what truly is mathematics.

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