“The Word Problem,” from Humble Pi: The Role Mathematics Should Play in American Education. Amherst: New York: Prometheus Books, 1994. (Chapter 3, pp. 77-96) Copyright 1994 by Michael K. Smith

> *Two trains leave at the same time but from different cities. One train is traveling west at 120 mph while the other is traveling east at 100 mph. Assuming the trains are traveling on opposite but parallel tracks, and the two cities from which they leave are 440 miles apart, how long will it take before they meet?*

It seems that every time I mention the train problem, whether it be in classes, professional meeting, or personal conversations, nervous laughter ensues. Practically everyone remembers the difficulties of doing word problems in high school math courses. Why are these problems so difficult and why do they evoke such bad memories? Do people have latent phobias about trains, perhaps caused by a primal archetype the even Jung overlooked?

In fact, the mere mention of “word problems” can produce some heated responses from those who have been through math classes. I once asked a group of undergraduates to respond to the term “word problem” with whatever came to mind. Some typical comments:

> Don’t like them because they make problems that are very simple very hard to understand. Torture - long, unnecessary word problems which make no sense.
>
> Tricks to fool the student.
>
> Yuk! I never did care how fast two trains heading in apposite directions were going or which one would get wherever first.
>
> Confusion - sitting at a desk trying to figure out what they are asking - have nothing to do with anything.
>
> Panic! Who cares? If a train leaves from NYC (100 mph) at 8:30 for Florida and a plane leaves at 2:30 Atlanta for NYC (300 mph) when will the two be at the same point?
>
> How do you spell a psychotic shriek?
>
> I think of stupid fictional Johnny’s riding across the town (approx. 8 miles) to get 8 apples for his mother and determining the cost of each apple.

Annoying, time consuming - When the hell are the trains from Chicago and LA going to hit each other?

Never seemed to serve any purpose, they were just assumed to be necessary. Two trains going in opposite directions … Word problems are senseless pieces of junk derived for the sole purpose of getting revenge on high school students. They were formulated by a psychologist who wanted to test the amount of stress the high school mind could take before a nervous breakdown.

Not all the responses were negative. Some students see word problems as challenging and stimulating brain teasers. But the fact remains that a good percentage of students respond negatively to this type of mathematics. This leads to two questions: Why the negative response? Why are word problems included at all?

What is the purpose of the word problem? Why is it included in math textbooks and what is it supposed to be testing? If you take a look at any high school text in algebra, you'll probably notice that word problems are not as common as other exercises. Most problem sets feature countless variations on some simple principle, as evidenced by the following examples from a typical page of homework. [1]

$$\frac{r^2 + 4r + 3}{r^2 - 8r + 7} \times \frac{r^2 - 2r - 35}{r^2 - 7r - 8} \times \left(\frac{r^2 + 8r + 15}{r^2 - 9r + 8}\right)^{-1}$$

$$(z^2 + z - 2) \times \frac{z^2 + z - 20}{3z^2 - 2z - 1} \,/\, \frac{2z^2 - 5z - 12}{2z^2 + 3z}$$

$$\left(\frac{a^2 - ab - 2b^2}{3a^2 - 7ab + 2b^2}\right) \times (a^2 + 4ab) \times \left(\frac{a^2 + ab}{6a^2 + 7ab - 3b^2}\right)^{-1}$$

$$\frac{15 - 13y + 2y^2}{4y^2 - 9} \times \frac{2y + 1}{1 - 2y} \,/\, \frac{5 - y}{2y - 1}$$

$$\frac{30 - 11c + c^2}{9c - 6c^2 + c^3} \times \frac{c^2 - 3c}{25 - c^2} \,/\, \frac{c^2 - 9}{c^2 + 2c - 15}$$

Most texts view mathematics as a symbol manipulation; learn, for instance, how $a^2 - b^2$ is factored, and practice this principle in endless drills which vary certain aspects of a particular technique.

When educational reformers talk about children doing more homework each day, these types of exercises take on even more importance. I'll never forget a conversation with a bright math honors student from a good high school in Tennessee. The young man had made a perfect score of 800 on the mathematics portion of the Scholastic Assessment

Test. When I asked how he did in high school math courses, he said they were good but very often he was bored by the assignments. I presented him with the exercises above and asked him to tell me how he would work on this assignment. He said that he would scan the page and look for what seemed to be the hardest problem and try to work it. If he failed, he would back up a bit until he understood the principle discussed. If he succeeded, however, he would stop, figuring he knew what was going on. Unfortunately, his teachers and parents didn't like this strategy and wanted him to do *his homework* and he had to work out pages of simpler problems.

The previous discussion is important in setting the context for word problems. Most math textbooks emphasize rote drill and abstract manipulation of mathematical techniques. After these exercise, word problems are presented. In a literal sense, we can see where they obtained their name - they are the only problems present that have *words* in them and not just symbols, such as xs and ys.

Word problems are supposedly real life applications of the mathematical principles under discussion. Since they are intended to expand upon the techniques presented, they naturally come at the end of a section. Learn the technique in the abstract and then practice it in more concrete applications. The intent, then, is laudatory: to show students how the mathematical principles they are learning are related to mathematical problems they will encounter in real life.

How well do problems in typical texts accomplish this purpose? My examination of numerous high school texts leads me to the following conclusions:

1. Word problems reinforce the idea that abstract symbol manipulation is the essence of mathematical thinking, since these types of problems view words as being merely transparent facades. In other words, look past the words to the real math involved.

2. Word problems are *not real*. They are often gross simplifications of real life situations masquerading as genuine problems. As such, word problems seem hastily constructed and poorly thought out.

3. Word problems create an attitude that to do well in math is to be able to think quickly and abstractly, to ignore complexities, and to search for the right answer. They imply that the real world is structured simply, and unequivocally, in mathematical terms.

To begin illustrating these points, let's examine some typical word problems and how students attempt to solve them. In an influential article on word problems, Nobel laureate Herbert Simon and his associates Dan Hinsley and John Hayes presented "data on the comprehension of those popular twentieth-century fables called algebra word problems." [2] To see if these word problems could be grouped into distinctive "types," they asked students to sort a number of problems taken from algebra textbooks into piles, with each pile representing similar problems. They found that 84 percent of all high school algebra word problems could be classified into eighteen clusters. Examples from ten of the clusters are presented in table 3. [3]

Table 3

1. TRIANGLE

Jerry walks 1 block east along a vacant lot and then 2 blocks north to a friend's house. Phil starts at the same point and walks diagonally through the vacant lot coming out at the same point as Jerry. If Jerry walked 217 feet east and 400 feet north, how far did Phil walk?

2. DISTANCE/RATE/TIME

In a sports car race, a Panther starts the course at 9:00 a.m. and averages 75 miles per hour. A Mallotti starts four minutes later and averages 85 miles per hour. If a lap is 15 miles, on which lap will the Panther be overtaken?

3. AVERAGES

Flying east between two cities, a plane's speed is 380 miles per hour. On the return trip, it flies 420 miles per hour. Find the average speed for the round trip.

4. SCALE

Two temperature scales are established, one, the R conversion scale, where water under fixed conditions freezes at 15 and boils at 405, and the other, the S scale, where water freezes at 5 and boils at 70. If the R and S scales are linearly related, find an expression for any temperature R in terms of temperature S.

5. RATIO

If canned tomatoes come in two sizes, with the radius of one being 2/3 the radius of the other, find the ratios of the capacities of the two cans.

6. INTEREST

A certain savings bank pays 3% interest compounded semiannually. How much will $2,500 amount to if left on deposit for 20 years?

7. MAX - MIN

A real-estate operator estimates that the monthly profit p in dollars from a building s stories high is given by $p = -2s^2 + 88s$. What height building would he consider profitable?

8. NUMBER

The units digit is 1 more than 3 times the tens digit. The number represented when the digits are interchanged is 8 times the sum of the digits.

9. WORK

Mr. Russo takes 3 minutes less than Mr. Lloyd to pack a case when each works alone. One day, after Mr. Russo spent 6 minutes in packing a case, the boss called him away, and Mr. Lloyd finished packing in 4 more minutes. How many minutes would it take Mr. Russo alone to pack a case?

10. NAVIGATION

A pilot leaves an aircraft carrier and flies south at 360 miles per hour, while the carrier proceeds N30W at 30 miles per hour. If the pilot has enough fuel to fly 4 hours, how far south can he fly before returning to his ship?

Later on I'll discuss why I think these problems are "not real." For now, let's continue with Simon and his colleagues' investigation of how students solve these typical word problems. The researchers next tested how quickly students could recognize a new problem as being one of these types. To do this, problems were read by the researchers in bits and students asked to categorize the problem and state what question was going to be asked. They found that over half the students could correctly categorize the problem after hearing less than one-fifth of the text! In other words, the mention of "Two trains…" almost immediately evokes a recognition that this is some type of distance-rate-time problem for those students who have learned this particular algorithm.

Simon and his associates did find that students use standard information to solve a word problem, if they can recognize it as one of the types. If the problem is nonstandard, i.e., does not readily conform to one of the familiar clusters, then they adopt a line-by-line solving strategy. But students will attempt first to categorize if at all possible. This means that if a word problem can be recognized as a distinctive type, then that person stands a much better chance of solving it

The solution processes involve very little creativity. Instead, the ultimate intent is: Can I recognize this problem as something that I've seen before so I can solve it? Simon and his associates found this to be true even if the problems were nonsense. For instance, which category does the following problem belong and how would you solve it?

> *Chort and Frey are stimpling 150 fands. Chort stimples at the rate of four fands per yump and Frey at the rate of six fands per yump. Assuming that Chort and Frey stimple the same number of yumps, how many fands will Chort have stimped when they finish?* [4]

This was easily recognized as a variation on the work-type problem and could be solved by ratios. If the words are meaningless and yet the problem can be solved, what does this say about learning mathematics? This confirms point 1 above: word problems are afterthoughts to the mathematical idea that symbols and symbol manipulation are the most important things one can learn from math. It also reinforces the notion that the "real world" is irrelevant: as long as something can be recognized as a type of mathematics, it can be solved.

The second point argued that word problems are gross simplifications of real-life situations. Take the train problem, for instance. In real life if two trains left separate stations at the same time, how long would it take for them to meet? I grew up around an uncle who worked for the L & N Railroad. He was stationed out of Knoxville and alternately did jobs as a brakeman, lineman, and conductor. When I was a child, he would take me on a passenger train from Knoxville to Cincinnati and back, in the days before the L & N Railroad discontinued passenger service. At the start of each trip, in my youthful impatience, I would ask him how long it would take to arrive. He always told me " trains move at their own speed"; after several trips, and several different arrival times, I began to understand the human comparison.

How realistic are some of the other types of problems in Simon's list? As a psychologist, I've always been interested in the "work" problems: questions such as, " If Sam can do a job in 5 hours and Bill can do it in 3 hours, how long will it take them working together?" Now, this can be calculated with an algebraic algorithm to determine an answer, precise to the second decimal place. But how useful is this? How long does it take two people together to finish a job? To me, this is a wonderful psychological problem: it involves factors of how well the people know each other, how important the job is, what time of day it is, what food and or beverages are available, is the boss around, is it Monday or Friday, are they in a good mood, and a thousand other variables. Now, we can estimate the combined time to completion but even this guess involves making a number of assumptions about group cooperation and working conditions. Ask any employer! To imply that this question has a precise answer is misleading to those trying to solve it.

Or consider another type, which did not make Simon's list but which I have encountered quite often: the age problem. Sample question:

> *Sally is five years older than her brother Bill. Four years from now, she will be twice as old as Bill will be then. How old is Sally now?*

First of all, who would ask such a question! Who would want to know this? If Bill and Sally can't figure it out, then this is some dumb family.

The impracticality of mathematics problems can be affirmed in a story told by the late Richard Feynman, Nobel laureate in physics. He was asked to serve on the mathematics textbook panel for the State of California, a group of educators, parents, and some professionals who are asked to help select textbooks for use in California public schools. To do this job well, he decided he needed to read all of the textbooks under consideration, an idea which he found was not adhered to by many of the other committee members. He ordered the books and a few days later three hundred pounds of them showed up!

As he was reading, he said he kept exploding like a volcano because,

> the books were so lousy. They were false. They were hurried. They would try to be rigorous, but they would use examples … which were *almost* OK, but in which there were always some subtleties. The definitions weren't accurate. Everything was a little ambiguous-they weren't *smart* enough to understand what was meant by "rigor." They were faking it. They were teaching something they didn't understand, and which was, in fact, useless, at that time, for the child.[5]

He cites an example of a word problem, trying to apply math to science. It read in part:

> red stars have a temperature of four thousand degrees, yellow stars have a temperature of five thousand degrees, green stars have temperature of seven thousand degrees, blue stars have a temperature of ten thousand degrees, and violet stars have a temperature of … (some big number).

As Feynman remarks, “There are no green or violet stars, but the figures for the others are roughly correct. It’s *vaguely* right-but already, trouble! That’s the way everything was: Everything was written by somebody who didn’t what the hell he was talking about, so it was a little bit wrong, always!” [6]

It got even worse when the question based on this information was posed:

> John and his father go out to look at the stars. John sees two blue stars and a red star. His father sees a green star , a violet star, and two yellow stars. What is the total temperature of the stars seen by John and his father?

Feynman reports that he would explode in horror: “Perpetual absurdity! There’s no purpose whatsoever in adding the temperature of two stars. Nobody ever does except, maybe, to then take the average temperature of the tars, but not to find the total temperatures of all the stars!” [7]

Feynman comments also on the pressures endured by members of the textbooks panels. They were offered gratuities indirectly by textbook companies, since the decisions of these committees often meant millions of dollars to publishers. With so much to read, many members would glance cursorily at the books under consideration. This is not to say this happens everywhere, everytime, but we can see the temptations: with so much money riding on textbook adoptions, do publishing companies have the luxury to produce high-quality, extremely well-written and well-thought-out texts?

The third complaint about the present way that word problems are structured is as follows: Word problems imply that to succeed in math we have to think quickly and abstractly, ignore complexities and go for the right answer. This has two implications: it hints that to do well in math is also to think well in general, and that most of the real world could be structured simply and unequivocally in terms of mathematics.

Nowhere can this be seen more clearly than in the mathematics test that high school students take every year, the Scholastic Assessment Test, or SAT. [8] SAT scores determine admission or nonadmission to colleges and universities for thousands of high school students each year. A poor score on this exam may overshadow good GPAs, good letters of recommendation, and years of outstanding classroom performance. Since the 1920s, and especially in the years after World War II, the SAT has grown in importance as a determining factor in the admissions process.

What is the SAT like? What types of mathematics does it test? A student taking the SAT would encounter several sections testing verbal ability and mathematical ability, along with one experimental section, which is used by the Educational Testing Service (the makers of the SAT and several others exams) to field-test new items. The student has a total of seventy-five minutes to solve sixty mathematics problems. Already it is obvious that time is at premium: ETS only schedules a working time of a little over a minute per problem. As might be expected, it is difficult to finish this exam. The way the test is scored, though, it is not necessary to answer all items to obtain a good score. The scale for this exam is from a 200 to an 800 with 500 being a good score, 600 very good, and 700 exceptional. Scores on this test are calculated by a corrected score as follows: number of questions answered correctly minus the one-fourth of the number of questions answered incorrectly. To receive a score of 500, a student needs a corrected score of about 50 percent, for a 600 a little over 65 percent, and for 700 about 85 percent.

The emphasis, though, is on speed and accuracy. Most of the questions are multiple choice with either four or five points. Test takers cannot argue with the SAT question. They have to learn to think the test makers' way, to avoid traps, and to understand what the test considers important. And what the test makers consider important is not always what is taught in high school mathematics courses.

Since I'm emphasizing word problems, let's look at some example SAT test questions. Consider the following item: [9]

> *In a race, if Bob's running speed was 4/5 Alice's, and Chris's speed was 3/4 Bob's, then Alice's speed was how many times the average (arithmetic mean) of the other two runners' speed?*
> *A. 3/5 B. 7/10 C. 40/31 D. 10/7 E. 5/3*

You can already sense the most common complaints high school students have about this exam: Why? Who would want to know this? We could ask, common-sensically, how much faster Alice is than Bob and Chris and then give us some speeds to work with. This problem, however, emphasizes the test taker's ability at translation: What do they want me to find, can I avoid being tripped up by the confusion of the mathematics, and can I essentially ignore the words to find the basic mathematical algorithm? Consider another question: [10]

> *Jim is now twice as old as Polly. In 2 years Jim will be n years old.*
> *In terms of n, how old will Polly be then?*
> *A. n/2 B. (n/2) + 1 C. (n/2) + 2 D. n + 2 E. 2n*

Here comes this dumb family again. Who would want to know this? We could ask how much older Jim is than Polly, but that would be too easy. Once again, you must come to think the way the SAT thinks in order to even want to attempt this problem. Also remember: you have one minute to solve it.

Let's try another one: [11]

> *Tom and Joe together earn $750 per week. If Tom's salary is two-thirds of Joe's, what is three-fourths of Tom's weekly salary?*
> *A. $187.50 B. $225.00 C. $275.00 D. $337.50 E. $375.00*

This one starts out OK. If they had asked Tom's salary, this might have been reasonable. Then we might have come close to comparing two workers and their respective salaries. But why do we need to know ¾ of Tom's salary unless they're trying to trick us?

One final example and one of my favorites: [12]

> *Initially, there are exactly 18 bananas on a tree. If one monkey eats 1/3 of the bananas and another monkey eats 1/3 of the bananas that are left, how many bananas are still on the tree?*
> *A. 4 B. 6 C. 8 D. 10 E. 16*

Need I comment on this one? Would some math-starved anthropologist sit around counting how many bananas are left on the tree? Or, once again, do the words not matter?

The SAT mathematics test is not entirely word problems, but all questions do emphasize speed and accuracy. The examples of word problems that I have presented, however, could be multiplied endlessly.

What is the Educational Testing Service up to? What is the purpose of the SAT? They publish a Little pamphlet, entitled *Taking the SAT*, which describes the function of the test and provides test-taking strategies and sample questions. The pamphlet is distributed free to all high school students and guidance counselors. Describing the mathematics section, the pamphlet says:

> The math questions test your ability to solve problems involving arithmetic, elementary algebra, and geometry. These verbal and mathematical abilities are related to how well you will do academically in college. The SAT does not measure other factors and abilities-such as creativity, special talents, and motivation-that may also help you to do well in college.[13]

Further on, it continues: "Some questions in the mathematical sections of the SAT are like the questions in your math textbooks. Other questions ask you to do original thinking and may not be as familiar to you."[14]

To a certain extent, they are right. They do continue the trend that has traditionally been set down by high school textbooks and focus on abstract mathematical principles or word problems which are essentially meaningless but can be mastered with enough practice. They just carry it to an extreme. A total of sixty questions can determine or influence a student's career. The pressure can easily mount as students' lives get determined by how well they can solve the types of problems listed above. Monkeys could determine your future.

The Educational Testing Service also claims that it does not measure other factors that may contribute to college success, such as creativity and motivation. However, I would disagree to some extent: given the pressure of the SATs in determining college admissions, they have encouraged the creativity and motivation of some students to figure out how to beat the SAT. In other words, any help that can be received to improve scores on the SAT is often gladly paid for by students or their parents.

Test preparation does work! I've taught preparation courses for a number of years now in the Knoxville area and I can say, without reservation, that you can teach a student to take the SAT. Now, the student has to be motivated, i.e., understand that it is important to improve his or her score. This motivation can come from the students themselves or from parents or guidance counselors encouraging them to improve their chances of selecting a good college or university. ETS boldly claims that these types of courses don't work. From the aforementioned pamphlet on special preparations for the SAT we find:

> There is a bewildering array of courses, books, and computer software programs available to help you prepare for the SAT. Some of them do no more than provide the familiarization and practice that is described in the previous section. Others are intended to help you develop your mathematical and verbal skills. These are often called "coaching" courses and we are often asked whether they work. Some students may improve their scores by taking these courses, while others nay not. Unfortunately, despite decades of research, it is still not possible to predict ahead of time who will improve, and by how much, and who will not. For that reason, the College Board cannot recommend coaching courses, especially if they cost a lot or require a lot of time and effort that could be spent on schoolwork or other worthwhile activities. [15]

Many students and parent have made their decision: thousands enroll yearly in courses sponsored by Stanley Kaplan or the Princeton Review or in hundreds of smaller-scale special programs like the one I do. To show the ambiguity of ETS's position, one of the best-selling study guides for the SAT is published by ETS itself, entitled *10 SATS*, from which the previous examples were drawn!

How would I coach students to take the SAT mathematics section and receive a high score? I would first give them a review of high school arithmetic, algebra, and geometry. Then I would show them how ETS devises questions and what types to expect, especially in terms of algebra word problems. Finally, I would have the students practice and get used to the test and time limits, using ETS's material. I have experienced average gains of well over 100 points on the math sections and sometimes as much on the verbal parts of the test.

At this point, readers might want to ask, So what's the big deal? So what if you can improve scores? Well, the point becomes this: the test is more related to motivation and money; whoever has access to both gets the better colleges. Furthermore, since the SAT is not directly related to high school coursework anyway, it departs from what should be taught in the high school classroom.

The fact that scores can be increased on the SAT is still not my major problem with this exam. More importantly, the test contributes to two attitudes about mathematics which I feel serve to devastate student and public interest in mathematics in general. First, as mentioned earlier, it perpetuates the notion that to do well in mathematics is to work quickly, get the right answer, and ignore all complexities or real world applications. I have already voiced my complaints about this matter.

Second, it makes most people feel dumb. And I don't just mean dumb in mathematics, I mean dumb in everything. You'll recall that ETS claims the SAT is "related to how well you will do academically in college." Well, the proof on this point is far from clear. SAT scores seem to have some modest relationship with grades the first year in college but after that their predictive power breaks down immensely. In chapter 2, I mentioned the Wallach study demonstrating that SAT scores do not seem to predict real-life accomplishments.

Why should all entering freshmen demonstrate a knowledge of mathematics via the SAT? It can only be that we are still in the throes of believing that to do well in mathematics means a likelihood of doing well in other aspects of life. To do poorly in mathematics means that you should expect poor performance in other endeavors you choose. This attitude originated with the inception of the SAT in the 1920s. The first commission, devised to construct the test, stated one of its purposes: The "tests are so constructed that they put as little premium as possible on specific training, and more emphasis on potential promise as distinguished from prior accomplishment." Continuing, the commission said that "a candidate whose educational opportunities have been limited has a much better chance to show his real capacity in a test which is not a measure of specific preparation, and which is devised so that any person may find increasingly harder and harder problems in which to demonstrate his ability." [16]

In other words, your performance on this mathematics test helps us tell how smart you are and how well you'll do in all college courses. This is too strong. The test cannot accomplish this purpose. As Crouse and Trusheim argue, in their book *The Case Against the SAT*, there is evidence to indicate that the SAT may not add any more information that the high school record doesn't already provide in helping admissions officers select students for theirs school. In other words, do away with the SAT and the same students get in.

But the impact on mathematics education is where the major consequences are felt. Mathematics needs to change. It needs less rote drill, more problem solving, more real life applications, and greater care in problem construction. An attitudinal shift has to take place before mathematics is respected and enjoyed by a great percentage of the populace. The change has to start with the mathematicians and the teachers of mathematics. We'll see in a later chapter some attempts at this change.

And word problems, in their present format, must go. Instead, make them more real, challenging, and interesting, and be prepared to help students work them. My train problem would be as follows:

> *Two trains leave at the same time from different cities. The problem is to decide when these two trains would meet if they were traveling toward each other. First, consider if this problem is important enough to invest your time and energy in it. Second, decide what information, mathematical or otherwise, you would need to solve this problem. Consult whatever sources are necessary and don't forget to ask questions as you do so. Report back whenever you feel you have accomplished something worthwhile.*

Notes

1. Mary P. Dolciani, Robert H. Sorgenfrey, William Wooten, and Robert B. Kane, *Algebra and Trigonometry: Structure and Method* (Boston: Houghton Mifflin, 1977), Book 2, p. 221.

2. Herbert A. Simon, Dan A. Hinsley, and John R, Hayes, "From Words to Equations: Meaning and Representation in Algebra Word Problems." In Herbert A. Simon, *Models of Thought* (New Haven: Yale University Press, 1989), vol. 2, p. 469.

3. Ibid., p. 473.

4. Ibid., p. 471.

5. Richard P. Feynman, *"Surely You're Joking, Mr. Feyman!" Adventures of a Curious Character* (New York Bantam Books, 1985), p. 266.

6. Ibid., p. 267.

7. Ibid.

8. The SAT has recently changed its name from the Scholastic Aptitude Test to the Scholastic Assessment Test.

9. *10 SATs: Scholastic Aptitude Tests of the College Board* (New York: College Entrance Examination Board, 1983), p. 25.

10. Ibid., p. 34.

11. Ibid., p. 187.

12. Ibid., p. 107.

13. *Taking the SAT 1992 -93* (New York: College Entrance Examination Board, 1992), p. 3.

14. Ibid., p. 16.

15. Ibid., p. 4.

16. James Crouse and Dale Trusheim, *The Case against the SAT* (Chicago: University of Chicago Press, 1988), pp. 23 -24.

Smith, M. (1994). Humble Piâ€"The Role Mathematics Should Play in American Education. Amherst, NY: Prometheus Books.Google Scholar. Stager, G. (1997). Computationally-Rich Activities for the Construction of Mathematical Knowledge-No Squares Allowed. In D. Ingham (ed.) Proceedings of the 1997 National Educational Computing Conference. Eugene, OR: International Society for Technology in Education, p.12.Google Scholar. Tinker, R. and Haavind, S. (1997). Netcourses and Netseminars: Current Practice and New Designs. Published on the World-Wide-Web at: http://www.concord.org/publications/ Concord, MA: However, although mathematics plays an important role in shaping the social reality, the mathematics education that is provided in Mexico does not seem to acknowledge this role. 2. For instance, in the article SÃ¡nchez (2007), the perception of the role of mathematics within the Mexican educational system is discussed. In particular, it was intended to provide a modest answer to the question â€œwhat is the justication for teaching mathematics in Mexico?â€. This question is embedded in the more general problematique concerning the problem of justication in mathematics education (Niss, 1996, Ernest, You can write a book review and share your experiences. Other readers will always be interested in your opinion of the books you've read. Whether you've loved the book or not, if you give your honest and detailed thoughts then people will find new books that are right for them.Â Even after a lifetime of education dealing with small numbers there is a vestigial instinct that larger numbers are logarithmic; that the gap between a trillion and a billion feels about the same as the jump between a million and a billion â€" because both are a thousand times bigger. In reality, the jump to a trillion is much bigger: the difference between living to your early thirties and a time when humankind may no longer exist. Our human brains are simply not wired to be good at mathematics out of the box.