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The Word Problem and the Child

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After seven consecutive years of working with about 150 children (per year) solving word problems, I feel some understanding for what is happening...[This article] represents a college professor's view of children doing math.

INTRODUCTION

This article is concerned with a national problem in math education, namely, children after the third grade seem to show little interest in learning math by drill and practice. As the children grow up, they seem to remember very little of the math which they have seen. When they become college age, either they are in need of remedial math for college or they bring a weak math side to the large service sector of our society. We maintain that it will make all the difference in the math history of each child if a weekly junction can be made between the side of the child that does elementary word problems and the side of the child that handles any challenging intellectual activity. Exposing children to algorithm after algorithm or calculator solutions does not really cultivate the problem solving (or math) state of mind. What is more attractive and, hence, memorable, is the pattern which is being exploited by the algorithm or the calculator. Patterns and accompanying ideas are far more likely to capture and hold the interest of children. In a sense, patterns need to be discovered before they are conceptualized and committed to memory. Such discoveries come naturally when the child goes on a math pilgrimage which leads to the solution of a word problem.

There is no solid reason why children should not try to solve word problems every week for most of the year. Elementary problems can be solved with very few steps of math reasoning. Such word problems use the syntax of ordinary language, not some special syntax of math (or science). Also, any child has a personal history filled with trying to cultivate language. MIT professor, Steven Pinker, in his best selling book, "The Language Instinct," documents the existence of a strong instinct for language acquisition in every child until age six. Pinker's mentor, Noam Chomsky, said "Children develop these complex grammars rapidly and without formal instruction and grow up to give consistent interpretations to novel sentence constructions that they have never before encountered." Hence, a persistent and purposeful teacher who takes the time and energy to communicate word problems in a free flowing language which is a mixture of both math and English has a great ally inside the child, namely, an activated language instinct.

A WORD PROBLEM PER SE

As a point of reference for the rest of this article, we now offer an example of what we mean by an elementary word problem.

A Boston policeman has a work schedule which consists of working four consecutive days, then having two days off. Assume this pattern continues throughout the year, 2000, which is a leap year.

What is the exact number of days such a policeman will work during 2000?

Problems such as this, when solved using only your wits and imagination over an extended period of time, offer the best way for children to learn and to remember the math of the counting numbers: 1, 2, 3, 4, and so on. Words such as policeman, work, and schedule engage the child's conscious, if not the subconscious, helping the child get close to the problem. The presentation of the problem is common enough. There is some news (as in the newspaper or on the internet), stated in the third person, but some information seems omitted, and there is a question to answer. Initially, the child wants to guess at the answer, which is a nice way to break any paralysis. There then comes an attempt to penetrate the problem by seeing what physi-

cal world phenomena are being measured by counting numbers. A veteran problem solver tries to see if the words of the problem speak to some math counterpart inside himself or herself. Such math counterparts are built up over time. For example, patterns of numbers such as the multiples of six are constantly associated with a specific choice of words, say read aloud as 6, 12, 18, and so on, not unlike the words to a song. The pattern-word combination eventually becomes part of the child's recent experience with math. There is a noticeable look in the child's eye when a math pattern from the recent past is recognized. Once it is observed that multiples of six are involved, say in the given problem, the child needs the courage and self-confidence to try to do some math in spite of insecurities. Eventually, the child will reach a point where the insights that 366 is 61 times 6 and 61 times 4 is 244 days give the answer.

It does not take long for the child to realize that although the statement of an elementary word problem has a common appearance and the problem typically has one correct answer, there are many ways to approach the solution based on each individual's personal history. One thing which does not vary is the idea that numbers and patterns of numbers are "anchors" that one goes to when searching for a solution. Another regular feature is the reward that comes to the successful problem solver, i.e., a tremendous surge in energy which is reminiscent of the expression "innate enthusiasm."

BYPRODUCTS OF REGULARLY SOLVING WORD PROBLEMS

Although some children will take longer than others in acquiring the knack of solving such problems, each child is capable of acquiring the knack of solving such problems, given an appropriate setting. Also, it is worth the effort. This is because this activity puts you in touch with your creative side, makes you fashion conjectures and build frames of reference. It also gets you to gather yourself together, to move over to where the problem is as opposed to reaching from a distance, to attach yourself to the problem, making the problem into a personal companion, to exert self-control by choosing certain options over others, and, in general, to learn to leverage the integration powers of your brain to get the most production. This means that the child will visit often and become familiar with a certain state of mind. This state of mind becomes an intellectual force which can be brought to bear on non-math problems as well, such as how to hit a baseball, or, later in life, how to get a very first job. In fact, for some children whose brain is especially suited to it, this state of mind can even develop into a kind of philosophy of life where one sees any obstacle as a problem to solve.

Something remarkable happens when this problem-solving state of mind is brought to bear on elementary word problems. The child gradually appreciates how to penetrate a context to fashion a bulls-eye, and to focus on the bulls-eye when both the context and the bulls-eye involve numbers. The child's natural imagination fuels efforts to attain proficiency in trial and error with numbers, to adjust guesses based on computations, to avoid paralysis while stumbling through reasoning about the natural numbers, and to try to find the right collection of numbers with which to deal. The energy to do this comes from the child's creative side; the resulting satisfaction, if not exhilaration, disposes the child to try to have the same experience again. In particular, the child can get a big kick out of connecting new patterns of numbers with old patterns and seeing how they fit together. All this results in a truly amazing evolution of a rookie problem solver into a veteran problem solver. Cultivating the brain's integrating ability to help solve elementary word problems actually develops a basic operating structure for doing new math in the future. Finally, the child will obtain a new view of the physical world and this view will be confirmed by getting additional problems correct.

THE MILIEU FOR CHILDREN SOLVING WORD PROBLEMS

Having indicated how solving word problems can help children be more self-sufficient in their later math efforts, we next address the issue of resistance to internalizing math information as it is typically presented today. What is offered is based on seven consecutive years of experience with a program being implemented at six different elementary schools in Boston, MA. It amounts to trying to maintain the children's interest through a social setting which gives due respect to both the nature of children and the nature of mathematics.

The format is a combination of a math team, practice once a week, and a contest once a month for five months (provided by George Lenchner's invention: Math Olympiads for Elementary Schools). Each prac-

tice lasts forty minutes and consists of going through seven word problems at the rate of five or six minutes per problem. Consecutive word problems may be independent of each other, so math information acquired in any one session will be modest and will be seen in a disconnected fashion. The practices feature lots of questions and answers, no one of which solves a problem but together point the way to a solution of the problem. A major role is played by the reality that hearsay in math is more reliable than hearsay in day to day life. Second and third hand information can be of good quality even though the messenger did not discover the information for himself or herself. The children learn directly from the problems and from each other; they learn indirectly from the teacher through the choice of problems and the little things in math that are emphasized. Concerning the monthly contests which had five problems to be done with no help from anyone, children who were rookie third graders were told to pick out one of the problems that appealed to them and to spend time on that one problem. Children who were veterans were told to start with whatever problem appealed to them, then go on from there.

As far as accommodations made giving due respect to the nature of children, the idea is that when children strain themselves creatively and get lost in a problem, they lose their balance. Thus, they need a gentle structure that will easily allow them to regain their balance. The environment should be one of utter civility, one void of extreme or dramatic action except when channeled into a math effort. All conversation should carry an air of dignity and respect, even those statements which are full of substance should be delivered with moderation.

It is in the nature of a child to talk about and compare problems with another child, perhaps even tease each other that one got the correct answer and the other did not. This conjures up the image of an environment which allows for a genuine sense of camaraderie among the children. Ideally, one would look for contributions to be made by those children who are presently not yet as skilled in math. This kind of child can add some inspiration to the group or try to encourage a sense of team spirit while working on a problem. For another example, a child's attention span is anything but constant; it rises, falls, grows, declines, and expands inconsistently. When working on problems, the environment should cultivate "volunteerism." A child not disposed to assert himself or herself should readily see examples of other children trying to assert themselves; a child should see examples of children with self-confidence and then aspire to have self-confidence too. As a final example, children tend to live in a world of impressions and ideas; formal technical behavior is foreign to them. Hence, the environment should value good ideas and partial solutions which are children's inventions even if they are not directly relevant.

CONCLUSION

In order to put this article in perspective, let us relate its content to well known large scale efforts in math education. The NCTM Standards of 1989 are being revised, and the draft of the new NCTM Standards is now available on the web. In Massachusetts, there is the Mathematics Curriculum Frameworks which was written in reference to the NCTM Standards. The core concept of the Frameworks is "Advancing Mathematical Power by having the students cultivate problem solving, communication, reasoning, and connections." One view of this article is that it attends to the Frameworks in a narrow (or compact), but organized way as far as certain problem solving is concerned. Another view is that it tries to get at the "why" of the Frameworks from the author's own experience of observing children doing elementary word problems for seven consecutive years.

In other words, thoughtful documents such as NCTM Standards or Massachusetts Frameworks still need to be interpreted for elementary school principals. The principals need something like a Global Positioning Receiver to help navigate the landscape of doing word problems. This article offers some help to such principals.

On another level, children are unfinished in many ways, but are growing and maturing, even quite apart from their teachers. Their ability to reason is naïve, perhaps, analogous to the way the immune system of very young children is naïve. Such children need help in correcting subjective and careless reasoning; they have to learn how to sit down by themselves and figure something out. In a broader setting, children need to understand that learning is valuable and to see that "real" learning and "school" learning are the same. This article offers a device that has done this for chil-

dren in the past.

Finally, there are questions that are ignored in this article. One such question is how intrusively should technology be inserted into the problem solving context. A deeper question is what role does the subconscious play in learning math through word problems, or, in general, in any challenging intellectual activity. Partial answers to these questions may very well come from similar endeavors as this one i.e., a math educator attending to certain aspects of the NCTM Standards or the Massachusetts Frameworks.

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Written to Me Upon Getting a B in Linear Algebra

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A revised version of a poem by Serge J. Zaroodny

Like a warrior returning from a fight,
    Who doth return himself, but minus foot,
The which his victory redeemeth not aright,
    For he would rather have that, than his loot.

Or like a knight returning from a fray
    Wherein his mighty foe he did o'erwhelm,
Yet cannot bid his thoughts to cease to stray
    To broken shield, dead horse, and ruptur'd helm;

Or like a boxer coming from the ring,
    Where the remains of his opponent lie,
His champ'onship deems well worth suffering,
    Yet feels his head and ribs and hopes to die;

Ah, sweet the quest, but better yet without it!
My Linear Algebra! Thus do I feel about it!