Mathematics and the Federal Debt

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Numbers in the billions and trillions are becoming common in describing social conditions in the United States and the world. The federal deficit of the United States in 1992 had been estimated to be $332.7 billion with a total national debt of $4.078 trillion. The population of the world in 1990 was estimated to be 5.292 trillion. The proven oil reserves of the world in 1989 were 1.0018 trillion barrels. The enormity of these important statistics does not show in the face value of the numbers. How can we help students to visualize these figures in ways that reveal their true magnitude? How can huge numbers like these be put into perspective by making meaningful comparisons and in seeing change through time?

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Grasping the immensity of huge social statistics is one aspect of "civic numeracy." Mathematician Lynn Arthur Steen wrote:

> Civic numeracy seeks to insure that citizens are capable of understanding mathematically based concepts that arise in major public policy issues. . . . A public unable to reason with figures is an electorate unable to discriminate between rational and reckless claims on public policy. (Steen 1990, 217–218)

The main sources of social statistics are from disciplines such as economics, political science, demographics, sociology, geography, and ecology. Are mathematics teachers in middle/junior and senior high school infringing on the area taught by social studies instructors if they pursue civic numeracy? Plainly, the two groups have a common interest that invites cooperation. Social studies educators can use the support of mathematicians in dealing with the burgeoning volume of social statistics. This sentiment is expressed in the National Council for the Social Studies bulletin, *From Information to Decision Making: New Challenges for Effective Citizenship.*

> As more and more information is formulated numerically, teachers and students ought to know about quantitative concepts that are useful in social analysis. (Laughlin et al. 1989, 7)

The National Council of Mathematics Teachers recommended the use of real-life numbers and problem solving in *Curriculum and Evaluation Standards for School Mathematics.*

> In a democratic country in which political and social decisions involve increasingly complex technical issues, an educated, informed electorate is critical. Current issues such as environmental protection, nuclear energy, defense spending, space exploration, and taxation involve many interrelated questions. Their thoughtful resolution requires technological knowledge and understanding. In particular, citizens must be able to read and interpret complex, and sometimes conflicting, information. (National Council of Teachers of Mathematics 1989, 4)

In a mathematics course for preservice elementary teachers, students were asked the size of the national debt. Some knew that the number was about $4 trillion and when asked what the number really means, their response was that the number is very large but did not have much meaning in their lives. We then discussed the importance of visualizing large numbers. We decided that the computer could help put the size of the national debt in perspective by counting up to 4 trillion. We entered a simple basic program into the classroom Apple IIe, and the program was started with the starting time recorded. To enter the basic program, one types *new* to tell the computer a new program is being created, and then enters the text as listed below. After the lines have been listed, type *run*, and the computer will start counting with the numbers rapidly scrolling down the screen. The same code will work on an IBM-compatible computer. A simple counting program that will run on the TI-81 programmable calculator and will count one dollar every second is also displayed in Table 1.

After the program had run for 15 minutes, we noted how many numbers had been counted and then looked at ways to calculate how long it would take the Apple IIe to count up to 4 trillion.

When the class did the ratio calculation, very few accepted their results the first time because the answer seemed unrealistic since, from the students' perspective, the computer seemed to be counting very fast. Their calculations came up with the following results: The Apple IIe counted approximately 31,500 numbers in 15 minutes, and at this rate, the resulting number of hours

TABLE 1—Two Computer Programs for Demonstrating the Size of the National Debt

BASIC Counting Program

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NEW
10 LET N=0
20 N=N+1
30 PRINT N
40 GOTO 20
RUN
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TI-81 PROGRAMMABLE Counting Program

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CALCULATOR PROGRAM
0 STO X
Lbl 1
X+1 STO X
IPART ((X/18.15)*10)/10 STO T
Clr Home
Disp T
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for the computer to count to 4 trillion would be 31,746,031.75 hours. We divided by 24 to change this number into 1,322,751.323 days and then divided by 365 to change the counting time into 3,623.976 years.

This definitely caught the students' attention and put the deficit into a perspective they could relate to. We let the computer count continuously for a week with a sign posted by the computer describing what it was doing. The counting activity was of interest during the week to other people who used the room, including the custodial staff. One of the custodians commented to me that he had read the poster and checked the progress of the counting each evening while he cleaned the room. As the computer continued to count throughout the week, the size of the number 4 trillion was put in better perspective and helped the individuals involved ask better questions of the candidates in the upcoming election.

The size of the national debt needs additional mathematical analysis to give a better perspective. Table 2 shows related information.

The following questions led students to explore the dimensions of the debt of the nation:

1. With a federal debt of $4.0788 trillion in 1992, how long would it take to pay off the debt if the government paid $1 million dollars per day? (To make the problem manageable, one should ignore the fact that the debt and income are growing each year.) Answer:

$$\$4{,}078{,}800{,}000{,}000 \div (1{,}000{,}000 \times 365) = 11{,}177.5 \text{ years.}$$

2. If you have a $25,000 income, what size debt would you need in order to have the same ratio of income to debt that the federal government had when the federal government income for 1992 was $1,075,700,000,000 and the federal debt was $4,078,800,000,000? Answer: $94,794.09 debt. On the surface, this does not look impossible. As an analogy, a family with an income of $25,000 might consider buying a $95,000 house. However, in the example, the family does not get the house. The grandfather bought the house and left the debt but not the house. Actually, the grandfather spent the money on health care, military arms, environmental protection, social security, and so forth.

3. A rich nation can afford a larger debt than a poor nation. From 1970 to 1992, the United States gross domestic product (GDP) increased significantly, as shown in Table 2. What percentage was the federal debt of the GDP in 1970? What was the percentage in 1992? In proportion to GDP, are we going deeper into debt? Answer: In 1970, the federal debt was 38.64% of the GDP; in 1992, the federal debt was 69.54% of the GDP. Yes we are going deeper into debt!

4. Our nation has debt by state and local governments and private debt as well as the federal government debt. The data on state and local and private debt are not available in the most recent 1992 *Statistical Almanac*. Using information from previous years shown in Table 1, project the state and local debt and also the private debt from 1985 to 1992. Make an estimation. How does federal debt compare to your estimation of state, local, and private debt? Add all three classes of debt together. This is a legacy to future generations.

Answer: The answers for this question will vary depending on the chosen method of solution. There is not enough information to make the kinds of precise calculations that mathematicians prefer. The point of the problem is to determine if the addition of other forms of debt are negligible in comparison to federal debt or whether the other debt makes the national burden even more horrendous for future generations. State debt in 1992 has been presented in the press recently as rising significantly because the federal government has been mandating programs for states but not providing money to support them. The state debt may now be a trillion or more. That is a guess. Private debt is also likely to be significantly higher than in 1985. This could easily add another trillion dol-

TABLE 2—Information Related to Mathematical Analysis of National Debt

Year	Federal debt (billions of dollars)	Gross domestic product (billions of dollars)	Federal deficit (billions of dollars)	State and local debt (billions of dollars)	Private debt (billions of dollars)
1970	380.9	985.6	−2.8		131.6
1975	541.9	1,511.0	−53.2		204.9
1980	908.5	2,644.5	−73.8	335.6	350.3
1985	1,817.0	4,219.6	−212.3	568.6	592.1
1990	3,026.3	5,459.5	−220.5	NA	NA
1992	4,078.8	5,865.0	−365.2	NA	NA

Sources: 1991 *Statistical Almanac of the United States* and *Economic Report of the President, February 1992.*

lars. Two trillion on top of the $4 trillion of federal debt is a significant addition. Other answers by students can be equally plausible.

This lesson on debt is certainly important to future citizens. The problem is that it straddles the boundary between mathematics and social studies. From the mathematics point of view, the problems posed above are important and require the use of many of the skills taught in mathematics courses. Problem 4, in particular, models some important problem-solving skills that have been stressed very little if at all in the past. Traditionally, mathematics students are given problems that have one right answer, and they can look the answer up in the back of the book or ask the teacher if they have the correct answer. The solutions to problem 4 require the students to make some conjectures and then, depending on their conjecture, come up with a defendable solution. Some important mathematics skills can be used and enhanced in the solving of this problem such as: estimation, interpolation, extrapolation, percentages, averages, ratios, comparisons, graph interpretation, and understanding of basic arithmetic computations and their appropriate use. This is a problem that does not lend itself to the traditional model where a student would work on the problem in isolation. Because a number of decisions must be made before computations can be made, the problem has to be discussed within a cooperative group. Students will be expected to work with others to solve problems all of their lives at work and in their community, and it is important that they have problems posed to them in mathematics, social studies, and other disciplines that require group efforts and the use of knowledge from a variety of subject areas.

In social studies, the government debt is germane to courses in citizenship, political science, and economics. It is unlikely that a social studies teacher will pose the mathematical problems that can clarify the numbers for students because this is not the way most social studies are taught. It is equally unlikely that mathematics teachers will pursue topics like gross domestic product. Teachers have an opportunity to consult with each other and provide problem-solving situations that will help build knowledge in related subject areas. Teachers tend to work in isolation, like the students in a traditional mathematics classroom, and great benefits are in store if they are willing to take the risk of stepping out of the comfort zone.

If students are expected to work together, it seems reasonable that they could learn from seeing their teachers model this in their own working environment. Students should be made aware of the communication that takes place among teachers in the preparation and implementation of lessons. (Do as I do, not only as I say!) It is important to make connections between subject areas, and this will require communication among teachers. The following quote from the *1989 Curriculum and Evaluation Standards for School Mathematics* reinforces this idea:

> The fourth curriculum standard at each level is titled *Mathematical Connections.* This label emphasizes our belief that, although it is often necessary to teach specific concepts and procedures, mathematics must be approached as a whole. Concepts, procedures, and intellectual processes are interrelated. In a significant sense, "the whole is greater than the sum of its parts." Thus, the curriculum should include deliberate attempts, through specific instructional activities, to connect ideas and procedures both among different mathematical topics and with other content areas. (National Council of Teachers of Mathematics 1989, 11)

Social sciences scholars increasingly use numbers in research. Most major social concepts can be clarified by classification, counting, and measurement. This growing use of numbers is just beginning to carry over into social studies classes in middle/junior and senior high schools. The walls of tradition separate the mathematics department from social studies. As with the wall in Germany, the time has come to break down these walls.

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