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Mathematics for Life and Society

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MATHEMATICS FOR LIFE AND SOCIETY

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ABSTRACT

A course (3 credit) by the title above was developed and taught to adult evening students as an alternative to a Basic Skills and Elementary Algebra remedial course. Quantitative concepts were acquired by extracting these from concrete social, economic and political problems of direct interest to the students. Applications considered were, for instance: The Consumer Price Index; Optimizing mass transit fares; Estimating world food and energy production; Population growth and extinction; Keynesian multiplier effect etc.

The student body of University College, Rutgers at Newark, where I taught for some 25 odd years consisted of adult evening students of many different backgrounds and of all ages. Many were minority women who would get up at 5 a.m. to cook dinner, clean the house and send the kids off to school. They came to class after a day's work and then returned home to do their homework. As mothers they saw to it that their children did well in school. One of my students between her and her husband's, raised twelve children all of whom were in high school or college. They were remarkable people all!

Approximately two thirds of the students received a failing grade in mathematics or withdrew. A poor education in the lower schools, accumulated anxiety and a lack of conviction that mathematical skills were of much benefit to their lives, combined to create a block towards achievement in the required remedial mathematics courses. To make matters worse, for a part of the twenty odd years that I taught these courses (I nearly always taught a remedial math course per semester), the New Math fad raged and textbooks demanded long theoretical arguments to "prove" the validity of the most elementary algebraic manipulations — while doing little to enhance the students' ability and confidence in applying quantitative skills.

"What use is all this mathematics to us? Why do we have to learn about these x's and y's?" they complained. I argued in vain that a quantitative insight into social and economic problems and data is essential to each citizen, if he is not to be deceived by the powers-that-be in our present day society.

I decided to try a novel approach. Under a grant from the Rutgers Educational Development Foundation I developed a course entitled MATHEMATICS FOR LIFE AND SOCIETY. Concrete practical problems in the social, economic and political domain of direct interest to the students were presented; clusters of applicable mathematical skills and concepts were extracted in the process of solving these. The intention was to make the mathematics sufficiently simple so that the students could learn and see its use simultaneously.

Topics covered in the course of one semester were Estimation and Powers of Ten; Variables; Linear Equations and Systems of Equations; Relation Notation; Functions and Graphs; Mathematical Trees; Combinations and Permutations.

Our first class consisted of a pep talk. I told a story of a bailiff at King Arthur's court who used Roman numerals to tally the taxes collected. He was deposed and beheaded by the King in favor of a "mathematical genius" like one of my students, who used decimal notation to perform the same task in no time flat. In the same vein, skills accessible to many today — such as solving complex problems with the use of computer programs — were accessible only to a highly trained mathematician some thirty years ago. An ordinary programmer secretly using a computer would be a "mathematical genius" in the mathematician's opinion.

This pep talk led to a review of decimal notation. The use of a familiar skill eased the students into the course and recalled power of ten notation.

We followed up with a preliminary discussion of the Consumer Price Index and proceeded to "stretch" this socioeconomic construct to cover many mathematical concepts. (It has been said that "one can stretch a word to cover the world.") A perusal of the C. P. I. table from its inception in 1913 until today showed how ratios, rates of change, percentages, proportions can be extracted from the numbers of the table to reveal the economic pulse of various time periods. (Why, for instance, was the rate of change small in World War II as compared to World War I? Because of price controls!). The concept of base year calls for the use of variables and formulas. The purchasing power of the dollar marks the notion of reciprocal, by which we shall learn to divide fractions. A compilation of the consumer basket prices over the years appears as a matrix. The total cost of the basket, calculated by weighted items, introduces the summation notation. The presentation of data in units of one thousand or a million justifies the introduction of scientific notation and the estimation with powers of ten. The shifting nature of individual and national priorities in assembling the items in the basket lends meaning to the mathematics of combinations and permutations. Finally a historical discussion of the C. P. I. alerts us to the importance of quantitative data in the functioning of modern society.

The course now moved back and forth between the qualitative and the quantitative, precipitating the mathematics — not necessarily in sequential order of topics, but rather introducing and returning to whatever skill was relevant — from the applications rather than vice-versa as is usually done.

SOME EXAMPLES

An application of Powers of Ten and Quadratic Functions

The following excerpt of a letter which appeared in the Bergen Record under the rubric *Port Authority needs a Math Lesson,* is an example of how these concepts were introduced in class:

> . . . We used the technique of Powers of Ten to estimate the total of tolls collected at rush hour daily and yearly on the George Washington Bridge. We considered the number of cars passing through a toll booth per hour, multiplied by the number of toll collectors. We arrived at a figure of some $42 million per year. This estimate — when checked against the not easily available Port Authority data was some $8 million short. Assuming an average salary per toll booth collector of $30,000 a year for 300 employees - this would absorb less than a fifth of the $50 million. Maintenance surely does not absorb the other $40 million. . .
>
> Another technique, that of finding the maximum point of a parabola, was employed to determine the optimum fare in a situation where every increase diminishes the number of consumers (demand under free competition). We found that beyond this maximum increases were counterproductive and diminished the total revenue. Perhaps it would behoove the directors of the Port Authority to study this simple theory. . .

Another Application of Powers of Ten

On the basis of a personal experience of a burglary in the City of New York and some available data, an estimate was made of the total yearly loot collected by burglars in the City. On the assumption that 1 in 7 of such crimes result in incarceration, it was found on the basis of an estimate with powers of ten that it would be considerably cheaper to disburse the average take at break-ins directly to the perpetrators.

Variables

The much feared x's and y's were introduced via tracing the progressive symbolization leading to increased abstraction in the history of writing:

Symbol Pictograph, Ideograph, Syllabary, Letter, Pronoun, Variable, Rebus
Domain Concrete Idea, Object, Word, Sound, Consonant,Vowel, Name of Object or Person, Natural Number

We introduced the notion of *substitution* through considering the pronoun as a variable:

She was a physicist who won the Nobel Prize.
Domain: all women physicists.
She was the first woman physicist to win the Nobel Prize.
Unique solution: Eve Curie.

From here on we clarify:

x is an even number.
Domain: all numbers.
$2x = 4$
Unique solution: $x = 2$.

Relation and Function Notation were introduced via pairings such as (Husband, Wife), (State, Capital), (Corporation, Rank), (Capital, Interest, Return). The representation in this notation of complex interrelations between many variables such as, say, the money allocated to education, child health care, housing, prison construction etc. teaches how to view social problems in a more abstract quantitative framework. Relations were formalized similarly to link taxation and investment policies to the quality of life and the competitive position of the U. S. etc.

A social vs. private cost benefit *matrix* to analyze the effect of the repealed catastrophic health bill was computed.

Numerical Functions and their Graphs were singled out as special cases of relations.

Polynomials were exemplified by:

The linear relation between yield per acre vs. amount of fertilizer applied in various regions of the world. The slope marks the productivity rate; the intercept the original level of agricultural production.

Calculating the optimum fare so as to yield the highest revenue to a mass transit line was used as a vehicle to discuss quadratic functions.

The dependency ratio, i.e. the ratio of wage earners to the total population — a quantity on which Social Security budget projections are based — was approximated with a third degree polynomial.

Powers of Ten once again were applied to compare items in the National Budget and to focus on the *order of magnitude* of military expenditures. The principle of exponential growth and the graph of the *exponential function* were then related to the growth of military expenditures and world population. The *negative exponential function* was applied to animal population extinction (blue whales). *Step functions* were made meaningful via population pyramids in various geographical and time periods.

Periodic functions appeared in cyclical fluctuations in grain production and the ensuing population in Western Europe in the period 1660–1860; and in relation to predator and prey population data.

The concept of *mathematical tree* precipitated from the principle of "Each one Teach Two" applied to wipe out illiteracy; similarly it applied to the conclusion that "we are all one human family" in tracing back the tree of generations some 2,000 years. The *multiplier effect* was similarly discussed in relation to the Keynesian Multiplier and the Social Spending Dividend as applied to the Head Start Program. Quoting once again from a letter to the Bergen Record entitled *The Social Spending Dividend:*

When Franklin Delano Roosevelt was inaugurated as president in 1933, he sought the advice of Alexander Sachs of Lehamnn Brothers on how to fight the depression. Sachs, following the Keynesian theory of pump-priming, suggested that every dollar spent by the federal government on public works would *multiply* through increased economic activity, jobs, and incomes and eventually produce more than enough tax revenue to cover the initial outlay.

. . . The Head Start program, which makes early childhood education available to disadvantaged children, by contrast has proven itself to be a *self-multiplying* and *self-liquidating* subsidy. The program started in 1965, has served and average of 500,000 three and four year olds a year — at an average cost of $2,500. The total cost of the program has been on the order of $13 billion.

It has reliably been estimated that for every $1.00 invested in this program, the savings to society in expenditures for health, remedial education and crime related activities *multiplies* to some $4.75.

This suggests that we calculate the dividends produced by socially useful projects, as they *multiply* and generate their own returns over the long term. Such a model of accounting could profitably be applied to, say, subsidized housing, in preventive health care, and job training of unemployed youth . . . .

Combinations and Permutations revealed the huge number of alternative ways of arranging our national priorities. Or the number of alternative sibling configurations in a four child family. Or the number of dances based on the nine fundamental movements of the belly dance. Or the huge variety of phenotypes resulting from the combinations in various groups of some twenty odd amino acids in the genotype's proteins.

The students were asked to write a term paper applying some of the skills learned. Topics of papers were, for instance: Election Campaign Financing, Gambling, Divorce: How does it relate to Juvenile Delinquency?, Owning an Apartment Building, Running a University.

Students performed distinctly better than in the standard remedial courses and quite a few went on to more advanced mathematics courses. The level of enthusiasm in the course was very high.

Below are some typical comments:

> Most of the class had a fear of math, like I did, and Prof. Yevick was able, over a few classes, to rid us of that very real feeling. Within a few weeks I was able to argue political questions using concepts I had learned in class. I could not only read, but understand the graphs used in the *New York Times*. Within ten minutes in a class one night, I was able to prove that every person in the world can be fed by using available land. The list can go on and on. The point is that I am more secure in my political choices, stock options and general interactions. I even used what Prof. Yevick taught me in a sermon in my church. . .

> I found the course to be a refreshing change from other math courses I took. Thus far I've taken Algebra, Probability and Statistics and Calculus and all of them seemed so irrelevant to the world. This course taught math from a practical standpoint . . . I might not have gone through college hating math so much and having anxieties about the topic when it was mentioned.

> Math for Life studies has equipped me with excellent math skills, technical expertise in problem solving, and the capacity to successfully learn other higher mathematic principles. Algebra, analytic geometry, statistics and other mathematical principles were creatively presented in class. After learning these principles they were applied to many areas of daily living, increasing our value and understanding of math . . .

> . . . Presently I am studying pre-calculus and maintaining a B+ grade in this course. Many of the concepts and skills learned in the Math for Life course enabled me to do well and expand my math education . . .

> In conclusion, I hope that a new and continuing student body will be given the opportunity I had to see a fantastic view of the world of mathematics. . .

Chapters from my manuscript *Mathematics for the Billions* and supplementary class notes and exercises written by me were used as class materials. (This manuscript is looking for a publisher.)

Mathematics for life was abolished as a course offering when University College was merged into the Rutgers Day College. I am interested in disseminating the methods and materials of this course by collaborating with others engaged in similar undertakings or by talking to teachers. The (copyrighted) manuscript is presently in Xeroxed form. If there is a sufficient demand, it could be put into a cheaper format for distribution.

To end, let me quote from Lancelot Hogben's best seller *Mathematics for the Million*:

> Fruitful progress can and will be made in solving the economic and political problems of the day when a large number of people will be thinking together about the same thing.

This course is based on the belief that to do so people must understand the basic quantitative tools with which to think these problems through.

ADDENDUM
MATHEMATICS AS A CONSCIOUSNESS RAISER
STREET MATHEMATICS

On the two nights when I returned from the meetings in San Francisco, I neglected to take off my badge. I was addressed on both occasions on the subject of math: once by an adult student of nursing on the trolley car; by a cab driver the other time. The future nurse — an A student except for math — worried about how to master the subject which she liked in spite of her struggles with it. The cab driver had just spent the evening working fractions with his son and discussed excitedly how the subject fascinated him, even though it was difficult.

I told my students in the *Math For Life And Society* course to think about mathematics when driving home from class, before going to sleep, while scrubbing floors or cooking dinner as I did very often. I told them that the benefits of such thinking extend beyond solving some particular math problem. The half hour a day, say, spent removed from pressing day-to-day concerns and the sudden flash of insight revealing the solution to a problem, help gain a broader perspective and activate clear thinking. The concentration enriches one's inner life and enhances one's general self-confidence. It, so to say, develops another thinking cap with which to view one's personal problems in a more abstract and social context.

During the latter half of the last century in Western Europe as well as during the Depression years here and there, free evening lectures for working people by academic volunteers or others were quite common. I personally am familiar with the cultural revival brought by Hans Polak, the founder of the Dutch *Diamant Werkers*

Bond, the diamond workers' union, to an impoverished and brutalized proletariat. He developed — among other things — an intense interest in Opera. The singing of arias became an accompaniment to the grinding of polishing wheels and their musical expertise increased the self-respect of the workers.

The philosopher, Susanne Langer in her book *Mind. An Essay on Human Feeling*, wrote that the human brain evolved in such a way as to have an independent need for self-assertion. This hunger of the mind feeds on imagination and action. Why not try mathematics to feed this hunger?

There is a lot of appetite for math out there in the streets, as one finds out soon enough in casual conversations about the subject. ("I wish I had learned more math." "I was never good at math because the teacher didn't make it clear," etc.) Perhaps we could appease some of this hunger by teaching relevant math on street corners or other places. (Bring a placard saying perhaps: "Powers of Ten Explained Tonight To Help You See Our Budget Priorities") and bringing along enough "tutors" to help those who wish to understand. Nor let us forget the work we might do with even little children. I have seen a change in self-esteem in a five year old black boy to whom I taught addition during a long train ride. We could involve ourselves in Head Start programs and so help grow a generation of mathematically competent minority children.

If a large number of people are "to think together about the same thing," as stated by Lancelot Hogben, we can do no better than to help them acquire the tools and thereby the self-confidence to do so.

Let's rap mathematics. Mathematical consciousness raising can stir the imagination and free people's pleasure in and courage to think.