MATHEMATICAL EDUCATION AT A HIGHER METALEVEL: APPLIED MATHEMATICS AS SOCIAL CONTRACT

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ABSTRACT

The author takes the position that mathematical education must redefine its goals so as to create a citizenry with sufficient knowledge to provide social backpressure on future mathematizations. This can be accomplished by increasing the part of mathematical education that is devoted to the description and interpretation of the processes of mathematization and by allowing the technicalities of the formal operations within mathematics itself to be deemphasized or automated out by computer.

INTRODUCTION

As compared to the medieval world or the world of antiquity, today's world is characterized as being scientific, technological, rational and mathematized. By "rational" I mean that by an application of reason or of the formalized versions of reason found in mathematics, one attempts to understand the world and control the world. By "mathematized", I shall mean the employment of mathematical ideas or constructs, either in their theoretical form or in computer manifestations, to organize, to describe, to regulate and to foster our human activities. I want to emphasize that it is humans who, consciously or unconsciously are putting the mathematizations into place and who are affected by them. It is of vital importance to give some account of mathematics as a human institution, to arrive at an understanding of its operation and at a philosophy consonant with our experience with it, and on this basis to make recommendations for future mathematical education.

The pace of mathematization of the world has been accelerating. It makes an interesting exercise for young students to count how many numbers are found on the front page of the daily paper. The mere number of numbers is surprising, as well as the diversity and depth of the mathematics that underlies the numbers; and if one turns to the financial pages or the sports pages, one sees there natural language overwhelmed by digits and statistics. Computerization represents the effective means for the realization of current mathematizations as well as an independent driving force toward the installation of an increasing number of mathematizations.

The view that mathematics represents a timeless ideal of absolute truth and objectivity and is even of nearly divine origin is often called Platonist. It conflicts with the obvious fact that we humans have invented or discovered mathematics, that we have installed mathematics in a variety of places both in the arrangements of our daily lives and in our attempts to understand the physical world. In most cases, we can point to the individuals who did the inventing or made the discovery or the installation, citing names and dates. Platonism conflicts with the fact that mathematical applications are often conventional in the sense that mathematizations other than the ones installed are quite feasible (e.g., the decimal system). The applications are of ten gratuitous, in the sense that humans can and have lived out their lives without them (e.g., insurance or gambling schemes). They are provisional in the sense that alternative schemes are often installed which are claimed to do a better job. (Examples range all the way from tax legislation to Newtonian mechanics.) Opposed to the Platonic view is the view that a mathematical experience combines the external world with our interpretation of it, via the particular structure of our brains and senses, and through our interaction with one another as communicating, reasoning beings organized into social groups.

The perception of mathematics as quasi-divine prevents us from seeing that we are surrounded by mathematics because we have extracted it out of unintellectualized space, quantity, pattern, arrangement, sequential order, change, and that as a consequence, mathematics has become a major modality by which we express our ideas about these matters. The conflicting views, as to whether mathematics exists independently of humans or whether it is a human phenomenon, and the emphasis that tradition has placed on the former view, leads us to shy away from studying the processes of mathematization, to shy away from asking embarrassing questions about this process: how do we install the mathematizations, why do we install them, what are they doing for us or to us, do we need them, do we want them, on what basis do we justify them. But the discussion of such questions is becoming increasingly important as the mathematical vision transforms our world, often in unforeseen ways, as it both sustains and binds us in its steady and unconscious operation. Mathematics creates a reality that characterize our age.

How many university lecturers, discoursing on numbers, say, allow themselves to discuss where they think numbers come from, what is one's intuition about them, how number concepts have changed, what applications they have elicited, what have been the pressures exerted by applications, how we are to interpret the consequences of these applications, what is the poetry of numbers or their drama or their mysticism, why there can be no complete or final understanding of them. How many lecturers would take time to discuss the question put by Bertrand Russell in a relaxed moment: "What is the Pythagorean power by which number holds sway above the flux?"

APPLIED MATHEMATICS AS SOCIAL CONTRACT

I shall emphasize the applications of mathematics to the social or humanistic areas though one can make a case for applications to scientific areas and indeed to pure mathematics itself.

Today's world is full of mathematizations that were not here last year or ten years ago. There are other mathematizations which have been discarded. How do these mathematizations come about? How are they implemented, why are they accepted? Some are so new, for example, credit cards, that we can actually document their installation. Some are so ancient, e.g., numbers themselves, that the historical scenarios that have been written are largely speculative. Are mathematizations put in place by divine fiat or revelation? By a convention of Elders? By the insights of a gifted few? By an evolutionary process? By the forces of the market place or of biology? And once they are in place what keeps them there? Law? Compulsion? Inertia? Darwinian advantage? The development of a bureaucracy where sole function it is to maintain the mathematization? The development of businesses whose function it is to create and sell the mathematization? Well, all of the above, at times, and more. But, for all the lavish attention that our historians of mathematics have paid to the evolution of ideas within mathematics itself, only token attention has been paid by scholars and teachers to the interrelationship between mathematics and society. A description of mathematics as a human institution would be complex indeed, and not be easily epitomized by a catch phrase or two.

The employment of mathematics in a social context is the imposition of a certain order, a certain type of organization. Government, as well, is a certain type of organization and order. Philosophers of the 17th and 18th-century (Hobbes, Locke, Rousseau, Thomas Paine, etc.) put forward an idea, known as social contract, to explain the origin of government. Social contract is an act by which an agreed upon form of social organization is established. (Here I follow an article by Michael Levin.) Prior to the contract there was supposedly a "state of nature". This was far from ideal. The object of the contract, as Rousseau put it, was "to find a form of association which will defend the person and goods of each member with the collective force of all, and under which each individual, while counting himself with the others, obeys no one but himself, and remains as free as before". In this way one may improve on a life which, as Hobbes put it in a famous sentence, was "solitary; poor, nasty, brutish, and short". The contract itself, whether oral or written, was almost thought of as having been entered into at a definite time and place. Old Testament history; with its covenants between God and Noah, Abraham, Moses, the Children of Israel, was clearly in the minds of contract theorists. In the United States, political thinking has often been in terms of contracts, as in the Mayflower Compact, the Constitutions of the United States and of the individual states, the Establishment of the United Nations in San Francisco in 1945, and periodic proposals for constitutional amendments and reform.

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A mathematized and computerized world brings with it many benefits and many dangers. It opens many avenues and closes many others. I do not want to elaborate this point as I and my co-author Reuben Hersh have done so in our book "Descartes' Dream", as have numerous other authors.

The benefits and dangers both derive from the fact that the mathematical/computational way of thinking is different from other ways. Philosopher and historian Sir Isaiah Berlin called

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attention to this divergence when he wrote "A person who lacks common intelligence can be a physicist of genius, but not even a mediocre historian". For the mathematical way to gain ascendancy over other modes is to create an imbalance in human life.

Because of widespread, almost universal computerization, with handheld computers that carry out formal manipulations and computations of lower and higher mathematics rapidly and routinely, because also of the growing number of mathematizations, I should like to argue that mathematics instruction should, over the next generation, be radically changed. It should be moved up from subject oriented instruction to instruction in what the mathematical structures and processes mean in their own terms and what they mean when they form a basis on which civilization conducts its affairs. The emphasis in mathematics instruction ought to be moved from the syntactic-logico component to the semantic component. To use programming jargon, it ought to be "popped up" a metalevel. If, as some computer scientists believe, instruction is to move from being teacher oriented to knowledge-oriented - and I believe this would be disastrous - the way in which the role of the teacher can be preserved is for the teacher to become an interpreter and a critic of the mathematical processes and of the way these processes interact with knowledge as a database. Instruction in mathematics must enter an altogether new and revolutionary phase.

CONCLUSION

Mathematics is a social practice. This practice must be made the object of description and interpretation. It is ill-advised to allow the practice to proceed blindly by "mindless market forces" or as the result of the private decisions of a cadre of experts. Mathematical education must find a proper vocabulary of description and interpretation so that we are enabled to live in a mathematized world and to contribute to this world with intelligence.

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