Talk - not published

THE POSSIBILITY OF UNIVERSAL MATHEMATICAL LITERACY

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1. We are facing a great crisis and a great opportunity. Changes in science and technology are tending to make semi-skilled labor obsolete. The demand for highly educated people, teachers, mathematicians, technicians, is rapidly increasing. Social and economic dislocation can only be avoided if we are able to educate to a high standard far more people than has previously been considered possible. The ability to think mathematically will have to become something taken for granted as much as ability to read a newspaper is at present.

   Such a change will seem fantastic to many people. But so would universal literacy have seemed absurd a few centuries ago.

2. Two possible viewpoints on twentieth century education.

   a. It represents a close approach to the best that is humanly possible.
   b. It represents the first gropings of a new society. Universal schooling is hardly a century old. Its standards of efficiency may be compared to the standards of industrial efficiency in 1750.

3. Parents in bringing up their children are guided by memories of their own childhood. But the community today has no tradition of mathematical understanding, no general insight into the way mathematical ability develops.

4. To enter a new stage of history is always difficult. No moral criticism of individuals or institutions is implied in this description of the existing situation.

5. The population today divides sharply into those who hate and fear mathematics and a minority of mathematicians. Typical:

   a. "The Universal Fear of Mathematics." Title of a lecture by Professor Mario Salvadori (March 28, 1957. U.S.A.)

   b. Professor B. F. Skinner, (Harvard, U.S.A., 1954). "The figures and symbols of mathematics have become standard emotional stimuli. The glimpse of a column of figures, not to say an algebraic symbol or an integral sign, is likely to set off--not mathematical behavior, but a reaction of anxiety, guilt, or fear."

   c. John Maclean, ("Mathematical Gazette," May 1954, Britain). A long article showing that doctors, economists, and scientists who urgently need mathematics for their work, are so frightened of mathematics that they cannot use it. Quotes a professor of epidemiology, "literally 99% of medical men shudder when presented with mathematics of matriculation standard which they all reached at one time... It would be an exaggeration to say that I can talk about epidemiology in sensible terms to 1% of the post-graduate medical students."

The remarkable thing is that such an outcome is accepted as normal. It is as if physical education crippled 90% of the children taking it.

6. Education is essentially the direction of mental energy. Children have abundant energy looking for an outlet. If adult society provides a satisfactory outlet, hobbies develop into professions and adults find life in their work. If adult society fails in providing an outlet, a double disaster occurs. The child has no energy or enthusiasm for work; and the child's energies are left to find an outlet at random. Society has then abdicated its duty to educate.

7. At the various stages of development, a person's energies are concentrated on various objects which acquire the hue of romance-- e.g. riding a bicycle, getting into a basketball team, love and courtship, becoming rich or famous, doing creative work, getting some peace and quiet, etc.

8. Beauty is in the eye of the beholder. Any subject, any activity can acquire the halo of romance.

9. Thinking is extremely unsatisfactory and inefficient if the concentration of the mind by romance has not taken place.

10. This concentration cannot be achieved by direct conscious effort. It happens to you, like laughter or falling in love. But, like laughter, it can be brought about by a suitable stimulus.

11. This concentration is the main characteristic of genius--not, as some say, a high I.Q. Some people with I.Q. 200 are certainly not geniuses. And probably there have been geniuses whose I.Q.'s were not exceptionally high.

Isaac Newton, asked how he discovered his theory of gravitation, answered, "By thinking about it all the time."

12. "Genius is an infinite capacity for taking pains." A widely misunderstood saying--it is interpreted as saying that genius is an infinite capacity for drudgery, for conscious effort; in fact, genius is a matter of being so absorbed in what you are doing that you are unaware of exertion--compare parents when a child is in danger; children scheming to do something that is forbidden, etc. Quite the reverse of conscious effort.

13. G. H. Hardy on mathematics--"the one abiding pleasure of my life," "I love mathematics and should be utterly miserable without it."

14. Popular view--evidently Hardy, and other mathematicians who feel like that, quite different from other people.

Against this view--<u>There is an important quality that is common to human beings, from the genius to the mental defective. A genius has a lot of something we all have some of.</u>

This is well recognized in literary genius. We recognize a great writer by the echo he awakens in us. That means that we have the essence of greatness within ourselves. "A great poet makes us feel our own wealth." (Emerson)

15. Evidence that spontaneous, sustained enthusiasm for mathematics is not limited to persons of exceptionally high intellect.

a. W. Flemming (Mathematical Gazette, February 1955, Britain) quotes the report on Secondary Education of the Scottish Education Department--

"The dullness and futility of much school teaching of the subject has been thrown into relief by the remarkable interest taken and progress made by these same pupils in the mathematical work of the Air Training Corps."

He goes on to say, "many teachers were in fact amazed at the keen interest taken in mathematics by Service personnel during the war."

b. Two remarkable letters from a retired carpenter in England. He went to school about 1900 when English schools were at their most barbarous. He hated school. The one light in the darkness was algebra, though there were many things he found hard to understand. At the age of 65 he decided to start reading mathematics again. He was delighted to find that in the intervening 50 years, textbooks had improved and he could now understand. In a chapter by chapter commentary on his reading (logarithms, algebra, calculus), such remarks occur as, "I was hungry for this."

c. Miss Chisholm (Christchurch Normal School, New Zealand, 1955) on the response of 5-year-olds, and one older child, to Catherine Stern's arithmetic apparatus.

"No child in my room has difficulty with the Stern Number Apparatus. My dullest child (52 I.Q., 8 years old) in particular has gained great satisfaction from it and seems to want to possess it; it is most noticeable that when another teacher wants to borrow the apparatus, this girl almost hugs it and wants to deliver it safely to where it is to go; and then she watches closely for its return. In every way, she has brightened up since she has had the satisfaction of achieving something which others in the class can do. Her favorite expression is to tap the apparatus fondly and say, 'Fun!."

Here arithmetic is serving to develop the personality of a child with a very low I.Q.

16. It is quite natural that if a child of limited intelligence can only do one subject, that subject should be arithmetic. The judgments involved in thinking, "Is this the right block? No, that one's too long," and later associating the various blocks with 0, 1, 2, ..., and 9 are much simpler than those required to learn the 26 letters of the alphabet and the eccentricities of English and American spelling.

17. An American teacher, concerned with Grade 1 and Grade 2 work: "Arithmetic is the most fascinating subject for children. If the children had their way, we should be doing arithmetic all the time."

18. At what stage then do children stop pressing the teacher for more arithmetic, and the teacher starts driving them to it? Certainly most entrants to university have lost their enthusiasm for mathematics.

Whenever it occurs, there is no need for it to happen. Children could go right through school, experiencing mathematics as a challenge and a triumph.

19. Children working in Grade 1, with apparatus, are doing precisely what good research workers do.

They have a problem.
* They understand what the problem is.
* They really want to solve the problem.
- They guess an answer.
They test the answer for themselves.
If it does not work, they try something else.

20. In the rhythm of rote learning, all the emphasis is on the answer. In the rhythm of research, the emphasis is on the two items marked with a star in section 19.

21. We are all of us imprisoned in our habits. The essential of education is to foster correct habits. It is easier for a mentally defective child to develop the rhythm of research than it is for a normally intelligent adult who has been subjected to fifteen years of parrot learning.

22. In discovering something for ourselves, we have a sense of freedom and conquest. In memorizing something that another person tells us and that we do not understand, we are slaves.

23. The practical value of mathematics lies in the fact that a single mathematical truth has a multitude of applications. If children can handle numbers with confidence and enthusiasm, they will be able to apply arithmetic to any situation that later life may bring.

24. The topics and treatment of the mathematics syllabus should, therefore, be determined by the following principles:

a. The course must be enjoyable and generate steadily increasing enthusiasm in the pupils.

b. It should develop independence and activity of mind, curiosity, observation, and confidence.

c. It should make pupils familiar with the basic ideas and processes of mathematics.

25. Children live in the present. They feel that at any moment something tremendously exciting may happen. Successful teaching makes them feel that something tremendously exciting has happened. Preparation for the business worries of adult life does not meet this specification. Mathematics teaching is practical and purposeful only if it enables children to do better something they desperately want to do here and now.

26. G. H. Hardy's tests for a good piece of mathematical research; it should be simple, surprising, and fruitful. To Hardy, "fruitful" did not mean "having practical applications," but rather that it stimulated one to further interesting ideas.

Here, again, there is striking agreement between the values of an advanced mathematician and a child. Children are, for instance, strongly interested in "think-of-a-number tricks." These tricks have no direct utilitarian value, but they are simple, surprising, and stimulating.

27. Carpenter and Anderson, in their Grade 4 text, have examples such as--

1 x 7 + 1 = 8	
12 x 7 + 2 = 86	The children are asked to continue
123 x 7 + 3 = 864	the sequence.

Such examples are both enjoyable and mathematically valuable. They develop observation of regularities and interest in pattern. They point towards algebra and all higher mathematics, and towards scientific laws.

28. Such examples are significant alike for mathematicians, scientists, and technologists. It is most remarkable that they play an entirely subordinate role in most texts, and in the syllabus. Only after four years--towards the end of Grade 8--is arithmetical pattern allowed to blossom into algebra. Meanwhile, the syllabus seems to stagnate; hardly any new ideas occur. Instead, time is wasted on compound interest, discount, mortgages, income tax, etc.--equally boring to mathematicians and children.

"Business arithmetic" is a heritage from the counting house of 1860. Its practical value is nil in an age of calculating machines and ready reckoners. Most firms prefer to train their employees in their own bookkeeping system. On the other hand, the importance of algebra and of science has increased enormously.

29. In view of the interest felt by most boys in engineering and science, it is equally remarkable that these make no appearance in the arithmetic syllabus, and in the teaching of elementary mathematics.

A demonstration can be given of cardboard gear wheels. Reasons for choice of this apparatus:

a. It arouses genuine interest.

b. It permits pupils to discover simple laws for themselves.

c. It reviews elementary arithmetic without seeming to do so.

d. It motivates for topics, such as fractions, pi, geometrical constructions, algebraic formulae.

e. It also provides a motive for accuracy, since an arithmetical slip will ruin the design of a gear wheel system.

f. It provides the basis for further studies of interest to boys--
e.g. the gears connecting the hour and minute hands of a clock;
bicycle gears, etc.

In Leicester College of Technology, this type of teaching was used with pupils who already hated mathematics. A full account of the apparatus used has not yet been published.

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