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On the Teaching of Mathematics in Elementary Schools, and Its Continuity with the Teaching in Secondary Schools

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because he was able to express the demonstration more simply for the narrower range, as he did in Euc. X. 1, than for the wider one; and because the narrower range was sufficient for the geometrical applications. But this of course is mere speculation.

THE FUNDAMENTAL CRITICISMS OF THE FIFTH BOOK OF EUCLID'S ELEMENTS.

29. Let me in taking leave of the book sum up the fundamental criticisms on the text as it has come down to us.

(i) There is the point first noticed by Saccheri that Euclid in his demonstration of Prop. 18 assumed the existence of the fourth proportional to three magnitudes, of which the first and second are of the same kind.

Simson supplied a proof of Prop. 18 which is not open to criticism (see Art. 25).

(ii) There is the point noticed by Simson that Euclid in his proof of Prop. 10 assumes more about ratios than his definitions allow him to do.

Simson supplied a proof of Prop. 10 not open to criticism (see Art. 24).

(iii) There is the point noticed by Stolz that one of the three sets of conditions contained in the Fifth Definition is involved in the other two (see Art. 14).

(iv) There is the point, first published in 1897, which forms the main subject of this address, viz.: that the properties of *Equal* Ratios are all deducible from the Fifth Definition, and that it is not necessary to employ the Seventh Definition, which is concerned with *Unequal* Ratios, for this purpose.

When account is taken of these matters, the artificial character of the proofs, and the great difficulties resulting therefrom, all disappear.

CONCLUSION.

30. And here I bring my address to a close. I have endeavoured to tell you something of the contents of this great work, something of what it did not contain, but which it directly suggests; and I have tried to show you how near the line of argument runs to the ideas now accepted as giving an adequate account of the theory of irrational number.

I hope that I have at the same time succeeded in communicating to you some small portion of the affection and reverence I feel for this great masterpiece, perhaps the noblest monument of the Greek intellect.

It is a great treasure house of ideas. There are two doors to it. One, representing the Euclidean text, stands locked, bolted, and barred, and over it is written, "Let none but the accomplished mathematician strive to enter here." The other, representing the arrangement of the argument explained above, stands wide open for every one who has a knowledge of Elementary Algebra. If, as I hope, I have shown you that no one so equipped need despair of a welcome in this house, I shall be well content.

ON THE TEACHING OF MATHEMATICS IN ELEMENTARY SCHOOLS, AND ITS CONTINUITY WITH THE TEACHING IN SECONDARY SCHOOLS.*

ARITHMETIC has been until recently the only branch of Mathematics generally taught in the Primary School; and as this subject deals exclusively with numbers in their simplest and most practical form, it must, in the order of teaching, be the first introduced to the child. The premier place must also be awarded to it when considering the relative importance of the various branches composing the unity of Mathematics.

* A paper read before the N. Wales Branch.

During the last decade, however, Algebra and Geometry and even Trigonometry have been introduced into the Primary School by several teachers, and it is gratifying to find that the experiment has met with unqualified success. But how far mathematical unity can be pursued in the teaching of the Primary School is a matter of considerable debate, and a question that would be better left to the individual teacher to decide.

In the teaching of Mathematics there is a point beyond which the Primary School cannot go, just as there is a division between the Secondary School and the University. But where exactly that point is, it is a very difficult matter to determine. It varies according to the locality and the conditions under which a school labours. And yet to limit the extent of the work would rob the children of a part of their heritage, and quench the enthusiasm and individuality of the teacher.

Less than twenty years ago the work of the Primary School was set out in detail by the Education Department (as it was then called), and as an example of the style of work then asked for, I will read to you the following :

First Year (children of 7 and 8 years of age) : Notation and numeration up to 1000. Simple addition and subtraction of numbers of not more than three figures. In addition not more than five lines to be given. The multiplication table to 6 times 12.

Mental Arithmetic : Short exercises, not involving large numbers and dealing with concrete as well as abstract numbers, preparatory to the work of the next standard.

Second Year (children of 8 and 9 years of age) : Notation and numeration up to 100,000. The four simple rules to short division. The multiplication table and the pence table to 12s.

Mental Arithmetic : Same wording as above.

Third Year (children of 9 and 10 years of age) : The former rules with long division. Addition and subtraction of money.

Mental Arithmetic : As above.

Fourth Year (children of 10 and 11 years of age) : Compound rules (money) and reduction of common weights and measures, viz. avoirdupois weight, long measure, liquid measure, time measure, square and cubical measure.

Mental Arithmetic : As above.

Fifth Year (children of 11 and 12 years of age) : Practice, bills of parcels, and simple rule of three by the method of unity. Addition and subtraction of proper fractions with denominators not exceeding 12.

Mental Arithmetic : As above.

Sixth Year (children of 12 and 13 years of age) : Fractions, vulgar and decimal. Simple proportion and simple interest.

Mental Arithmetic : As above.

Seventh Year (children of 13 and 14 years of age) : Compound proportion, averages and percentages.

You will observe that almost all the teaching was concentrated upon Arithmetic alone, as if it were self-contained, with no relation to geometry and the physical sciences. The time expended upon working long, cumbrous, unnecessary examples was sheer waste. There was no practical or moral gain to the pupil, who might have been far more profitably employed by taking up another branch of the subject.

The great defects of the syllabus were :

1. It was based on the Text-Book and not on the development of the child-mind.
2. It ignored the knowledge acquired by the child out of school.

With the advent of the new century, the Board of Education, in publishing their typical schemes, granted to teachers the liberty to adopt them in their

entirety or to frame their own, subject to the approval of His Majesty's Inspectors. This was a concession heartily welcomed by the teachers, and although it imposed upon them more work and greater responsibility, it stimulated many to put into operation ideas that had been simmering in their minds for some time past. As a result, many original and intelligent schemes have been evolved, which, as far as can be judged at present, have proved eminently successful.

In the Infants' School practically no formal Arithmetic is taken. The little children have acquired first-hand knowledge of a pint of milk, a pound of butter, a yard of ribbon. Who knows better than a child at this age the buying capacity of a penny? The coalman with his cart and bell has a curious fascination for the child. Is it impossible that he has no idea of a cwt. of coal? That young children have some knowledge of the rudiments of geometry may be seen from their correct use of such words as: top, bottom, above, below, big, little, as far as, about the middle. These facts and experiences should be utilised at the earliest possible stage in the child's school life, and made the basis of the teaching in the science of number. If these experiences were noted and collated and allowed to crystallise, they would be of inestimable value in giving young children an all-round training, and would thus prepare the way for more advanced work in after years. It is true that this is not the method of the text-book, which as a rule commences with notation and numeration, and then proceeds to deal with each rule in succession. There is no book that can record on one page, or even in one chapter, the wonderful and varied activities of the human mind. We have also learned that there is a danger of striving after pedantic thoroughness by insisting upon a complete and accurate knowledge within a small compass of numbers. And this undoubtedly the "Committee of Fifteen" had in their minds when they reported some years ago: "The attempt to secure what is called thoroughness in the branches taught in the elementary schools is often carried too far; in fact, to such an extent as to produce arrested development in the mechanical and formal stages of growth. The mind in that case loses its appetite for higher methods and wider generalisations." Very true! The outlook at the beginning of his career was so dwarfed that the child became stunted in his mental activities. The background for young children should be as large as possible, yea, without boundaries—the real and the imaginary blending together in the most subtle and seductive manner. This I take to be the dominant characteristic of modern teaching as applied to the Primary Schools.

Generally speaking, the course now followed is somewhat as follows:

Instead of spending a whole year on addition and subtraction involving the use of hundreds, the teaching divides itself into four sections:

1. Practical and Experimental. 2. Mental and Oral. 3. Written. 4. Manual Work.

These divisions run concurrently throughout the years during which the child is in school.

Standard I. Inch cubes and laths are used for building up simple numbers involving no more than the tens; also dummy coins, ruler and tape, simple weights and measures (lbs. and oz., pints and quarts); the clock. No number to exceed 60.

Standard II. Subjects of Standard I. extended. Simple fractions; the decimal system with ruler for inches and tenths. Numbers not to exceed 99.

Standard III. Fractions, decimals; metric system (metre and multiples, etc., only); mensuration of simple areas. Algebra, use of symbols in the four rules.

Standard IV. Subjects of Standard III. extended ; easy proportion, plotting graphs for attendance, thermometer, etc. Algebra, use and meaning of $a+b$, $a-b$, $a \times b$, $\frac{a}{b}$; easy simple equations and problems.

Standard V. Harder exercises in I.-IV. Metric system, in which long names of multiples and submultiples are needless—they can be expressed decimally. Fractions in algebra.

Standard VI. All previous work thoroughly revised and somewhat extended. Percentages, averages, interest, discount. Graphs, charts, diagrams. Algebra, factors, simple fractional equations, simultaneous equations.

Standard VII. Simple surds ; A. and G. progressions ; easy indices and logarithms ; with a full course in Arithmetic.

Each section mentioned above opens out a well-nigh inexhaustible store of exercises and sub-exercises which only an interested and intelligent teacher can manipulate. And herein lies the secret of successful teaching of number to young children and the superlative need for careful thought and preparation on the part of the teacher to come before his class armed with all those weapons so essential to create interest in the work, and to draw the children almost unconsciously into the vortex of intensive mental effort.

Geometry might be begun much earlier, and theoretical geometry introduced.

Although this rough outline of what is being done is more or less applicable to all schools, especially in the earlier years, the work in the later years is very much curtailed and handicapped by the miserable requirements of some educational authorities for scholarships to be held in the Secondary Schools. Until this anomaly is removed, it will be utterly impossible for all schools to adopt a rational and an intelligent scheme similar to that I have just described.

Not till the fifth year do some children pass on to the County Schools with a fair knowledge of Arithmetic, Algebra, elements of Geometry and Mensuration.

Glanadda Council School, Bangor.

R. W. JONES.

ON THE TEACHING OF ELEMENTARY MATHEMATICS IN SECONDARY SCHOOLS.*

IN order to make this brief paper as practical as possible, I shall plunge into the subject with little introduction.

I wish to consider the question from three points of view.

- (1) What is the ideal course ?
- (2) What is the best practicable course ?
- (3) What effect the best practicable course should have on the teaching of the subject in our secondary schools, and also—since the two are so closely connected—in our elementary schools.

Of course, the chief difference between the ideal and the practicable largely arises from the fact that we are not able as teachers to frame our syllabus exactly as we wish ; external forces—chiefly our British external examination system—make us tone down our ideal into the practicable, but I hope to show that even with this limitation we can still do much to make our elementary mathematical teaching more efficient than it has been. And in what follows I wish it to be understood that I am thinking of the average child, though I may say that it is too often assumed that the elementary

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