THE RATIONALE OF ARITHMETICAL TEACHING EXEMPLIFIED IN A FULL EXPOSITION OF THE PRINCIPLES OF NUMERATION AND THE FOUR ELEMENTARY RULES, WITH REMARKS ON TEACHING ARITHMETIC

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The rationale of arithmetical teaching exemplified in a full exposition of the principles of numeration and the four elementary rules, with remarks on teaching arithmetic by John Blain

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WITH

Remarks on Teaching Arithmetic.

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THE

RATIONALE

OF

ARITHMETICAL TEACHING.

INTRODUCTORY REMARKS.

1. In the following section on Numeration, it is shown in order how to name and represent all numbers, from the simplest to the largest. It would not be proper to pursue the same course in teaching. The plan followed may be something like the following:—

2. Let the children be first exercised mentally, for some time, in the four fundamental rules with simple *concrete* numbers; notions of number being thus gradually acquired, the symbols for the first nine numbers may be taught; after clear ideas of abstract numbers have been acquired by calculations with these, counting by tens may be proceeded with, and the nature of local value and the use of the cipher taught; afterwards, counting by hundreds, thousands, &c., each stage being thoroughly mastered before the next is entered upon: an anxiety to get quickly through defeats itself in teaching the elements of any subject. Children have been very much amused with the following way of teaching the decimal scale, at the same time that they rapidly acquired clear notions of counting by tens. A child is taken

from the class, who stands before it and holds up a finger for every object to which the master points (the intention being to count the number of objects in the room); when the eleventh object, to which the master rapidly passes, is reached, the boy calls on him to stop, he has not eleven fingers. It is then determined that another boy shall stand out to hold up a finger whenever the first is ready to begin again: this process may be carried to any length. At the end columns are ruled, and the number of fingers each child has held up is registered in order.* It is then shown how the columns may be dispensed with; the necessity for the cipher will appear when the lines are removed in cases where there are none of any kind of unit. By such methods the children are led *naturally* to the decimal scale; they, as it were, discover it for themselves. It is very important to teach Numeration thoroughly, for the processes in Addition, Subtraction, Multiplication, Division, and the rules relating to Decimals are directly founded on its principles. The proposed introduction of a Decimal Coinage gives additional force to this remark.

3. Children, in general, are made to begin Slate-arithmetic too soon; they frequently do so when they hardly know the symbols for the first nine numbers. They have, in consequence, to encounter at once a multitude of difficulties, each of which should be conquered alone; such as the strangeness of the whole subject, the labour of adding, their unfamiliarity with the figures, and awkwardness in making them, and the process of carrying. They should have nothing to do with slates until they are *at least* sufficiently versed in mental calculation to perform promptly all the mental processes required in the fundamental rules. These rules are supposed to be explained in the following pages to those who have undergone this previous training.

* This arithmetical game, as it may be called, is simply the illustration used in Art. 9. of Professor De Morgan's Arithmetic, carried into practice.

4. In entering on any new rule, a question should first be proposed by means of which the requisite definitions may be brought in; if a new symbol of operation is necessary, this should next be explained; then, the principles employed in establishing the rule are to be illustrated by a sufficient number of examples, — these illustrations always *preceding* the formal statement of the principle, which must be *inferred* from them; after this, many examples of the kind required, from the simplest to the most difficult, must be done by the help of the principles previously elucidated; and, lastly, the pupils should be guided by varied forms of interrogation in deriving the rules for themselves by an induction from these examples. It is especially to be remembered, that in this process of demonstration the pupils must be *told* as little as possible: the intuitive or Socratic method of teaching is the one to be pursued here. In order to further the education of that important faculty, the memory, by training it to habits of retention and precision, every principle or rule, as soon as it is thoroughly understood, should be expressed in simple and precise language, and required to be learnt by heart and repeated without deviation. In attending to principles so as to develop the faculties of abstraction, attention, and reasoning, the teacher must take care to exercise his pupils sufficiently to render easy the application of these principles. It would be a great fault to enter so minutely on processes of demonstration as to neglect *practice* in a subject which bears so intimately on the concerns of every-day life as Arithmetic. *Facility*, *correctness*, and *neatness* in working, should then be looked after. All such words as *Addition*, *Sum*, *Excess*, *Product*, *Interest*, *Rate*, &c. should be explained, and precise explanations required in return, as it conduces much to clearness of thinking when a habit is acquired of requiring and giving correct definitions.

5. It is frequently urged against teaching Arithmetic demonstratively, that no time can be found for it, and that it in no way conduces to accuracy and quickness of working.

In order to remove these objections, and to show the necessity of making time for such teaching, it is sufficient to state what are the objects proposed to be attained by it. There are two ways in which, generally, we may look at any subject of instruction; we may view it as an *end* in itself, on account of its utility or the pleasure an acquaintance with it affords, or as a *means* for training some faculty or faculties, that is, as an instrument of education. It depends on what we seek to accomplish, to which aspect most prominence is given; but in every sound system of primary instruction, while the *subjects* are largely decided by the former, the *methods* will be entirely determined by the latter. Thus, Arithmetic, with which only we are concerned, may be taught simply in its connexion with the business of life; or, in addition to this, as a means of forming the attention and judgment, and developing the reasoning powers. In the former case, the teaching will be confined to the mechanism of calculation; in the latter, reasons will be given with rules, or rather, as formerly explained, the children will be led, by careful training, to prove the rules for themselves. Of the two courses here indicated, the latter is certainly the preferable one; for, although it is quite true that the most expert calculators are frequently those who are ignorant of abstract principles, and that long and laborious drilling is the only way to make one sure and quick in the use of numbers, yet it is more important that a boy should have a well-trained mind, than that he should be an expert calculator. Besides, attention to one part of the subject does not imply neglect of the other. In the education of those whose school-life is of limited duration, it is especially necessary that some elementary subjects be used as disciplinary agents, for it is to such subjects only that they have access, and if they are to be trained to sound intellectual habits at all, it must be by means of judicious instruction in them. It is then, as a mental gymnastic, as a means of imparting the art of thinking (if the expression may be allowed), and producing certain invaluable mental aptitudes, that Arithmetic is taught in the careful way above described, so that it may fill, in its measure, the same place in primary, that the Higher Mathematics do in superior education.

NUMERATION AND NOTATION.

6. If we wish to express that there is a single object of any kind, instead of writing *one*, for the sake of shortness we use the mark or *figure* 1

If to one thing we add another of the same kind, we shall have *two* things. Thus, *one* apple and *one* apple make *two* apples. To express this *number* we use the figure 2

If to *two* things we join *one* thing of the same kind, we shall have *three* things. Thus, *two* boys and *one* boy are *three* boys. This number is expressed by the figure 3

If to *three* we add *one*, we shall have *four* . . 4

Four and *one* are *five* 5

Five and *one* are *six* 6

Six and *one* are *seven* 7

Seven and *one* are *eight* 8

Eight and *one* are *nine* 9

If to the number *nine* we add *one*, we shall have the number *ten*.

7. In this way we may form as many numbers as we please, but it is plain that we cannot give fresh names to all of them; if we were to do so, we would at last be stopped by the impossibility of remembering these names, and thus we would not be able to reckon with very large numbers. A shepherd, for example, would not be able to state the number of sheep in a large flock. I am going to explain how all

numbers may be named by means of very few words in addition to *one, two, . . . nine.*

8. Suppose there are before us many objects, say marbles, which we wish to count. In order that we may be able easily to discover how far we had gone, if we happen to lose count, or to resume our task where we left off, after having dropped it for some time, we take ten out and put them aside by themselves (why this number is taken rather than any other will be noticed by-and-by); we take ten more out, and put them aside; ten more, and put them aside; and so on. A set of heaps is thus formed, each containing ten things. When there is *one* heap, we have counted *ten;* when there are *two* heaps, we have counted *ten twice;* when there are *three* heaps, we have counted *ten three times over;* and so on. The names of the numbers thus formed are shortened as follows:—

Two tens	into	*Twenty,*
Three tens	"	*Thirty,*
Four tens	"	*Forty,*
Five tens	"	*Fifty,*
Six tens	"	*Sixty,*
Seven tens	"	*Seventy,*
Eight tens	"	*Eighty,*
Nine tens	"	*Ninety.*

When we have taken out one heap, before the second heap is formed we shall have successively — ten marbles and one marble more, ten marbles and two marbles more, ten and three more, &c.; these numbers are named thus:—

Ten and one are *eleven,*
Ten and two are *twelve,*
Ten and three are *thirteen,*
Ten and four are *fourteen,*
Ten and five are *fifteen,*
Ten and six are *sixteen.*